RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

Vol. 45 JULY 1945 No. 1

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PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

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RADIOLOGY is entered as second class matter at Syracuse, New York, and Easton, Penna., under the Act of August 24, 1912, and accepted November 24, 1934. RADIOLOGY is published by the Radiological Society of North America as its official Journal. Subscription rate $6.00 per annum. Canadian and foreign postage, $1.00 additional. Single copies, 75¢ each. All correspondence relative to business matters connected with the Radiological Society of North America and RADIOLOGY, or remittance for non-member subscriptions, should be made payable to the Radiological Society of North America and should be addressed to the SECRETARY-TREASURER, DONALD S. CHILDS, M.D., 607 MEDICAL ARTS BUILDING, SYRACUSE 2, NEW YORK. In requesting change of address, both the old and the new address should be given.

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Intracranial Angiography[1]

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THE RAPID and extensive development of intracranial surgery during the past twenty years has been facilitated in great measure by the employment of x-ray procedures by means of which it is possible to investigate the skull and its contents in great detail prior to direct surgical exploration. The oldest and simplest of these, *x-ray examination of the cranial bones*, depends for evidence of underlying brain lesions upon the discovery of associated osseous abnormalities. A few lesions, characteristically associated with lime salt deposition in otherwise radiolucent tissues, cast recognizable shadows in their own right. Although this form of study is useful, it is often found wanting when the need for detailed diagnostic information is greatest.

Intracranial pneumography, which consists of the graphic portrayal of anatomical landmarks in contrast to gas temporarily introduced into cerebrospinal fluid spaces, enormously broadens the usefulness of x-rays. Many lesions entirely unrecognizable by ordinary radiographic methods may be identified and described in considerable detail when pneumography is employed.

Radiographic examination of the skull following the perfusion of intracranial vessels with radiopaque materials is known as *intracranial angiography*. Blood vessels, momentarily rendered densely opaque, serve as reference points in detecting disturbances of anatomical relationships produced by intracranial lesions. This method, very useful when vascular displacement provides evidence of disease in neighboring tissues, is of special value when the vessels are involved directly. In particular, the procedure offers a means of obtaining diagnostic information not otherwise available in suspected intracranial aneurysms, anomalies of intracranial vessels, certain cases of arterial occlusion, and expanding lesions involving one cerebral hemisphere which have not been accurately localized. Sometimes the vascular pattern provides an indication of the character of the pathological process.

Angiography, as applied to the arteries and veins of the extremities, has long been accepted as a useful procedure. The principle was first applied to the circulatory system of the cerebrum in June 1927, by Egas Moniz of Lisbon (1, 2), who injected the carotid system with 70 per cent strontium bromide. Of six patients so examined, one died as a result of the procedure. Twenty-five per cent sodium iodide was then substituted for strontium bromide,

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[1] From the Department of Surgery and the Department of Roentgenology, University of Michigan, Ann Arbor, Mich. Read by title at the Twenty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 1-2, 1943.

and approximately 200 patients were injected over a period of three years. Cerebral vessel shadows proved much more satisfactory in this group, but many of the patients suffered headaches, convulsions, and transient hemiplegia. In two instances death occurred. In 1931 Egas Moniz abandoned the use of sodium iodide and began to inject patients with thorotrast, which material he has used successfully since that date.

The significance of intracranial angiography was soon recognized in other European clinics. In Germany the method was introduced by Löhr and Jacobi in 1931 (3) and later was extensively employed for the diagnosis of brain tumors by Tönnis (4), Fischer (5), and Lorenz (6). In England carotid angiography was adopted by Dott (7) and by Jefferson and Northfield (8); in Sweden by Olivecrona. Physicians of North America have been slow to follow the European lead, the first protagonists of the method being Elvidge (9) and Turnbull (10) in Canada, Freeman and Watts (11) and Gross (12) in the United States. Expansion of the angiographic procedure to include the portions of the brain whose blood supply is derived from the vertebral arteries was first described by Egas Moniz, Pinto, and Alves (13) in 1933, and technical modifications were proposed by Sjöquist (14) in 1938 and by King (15) in 1942.

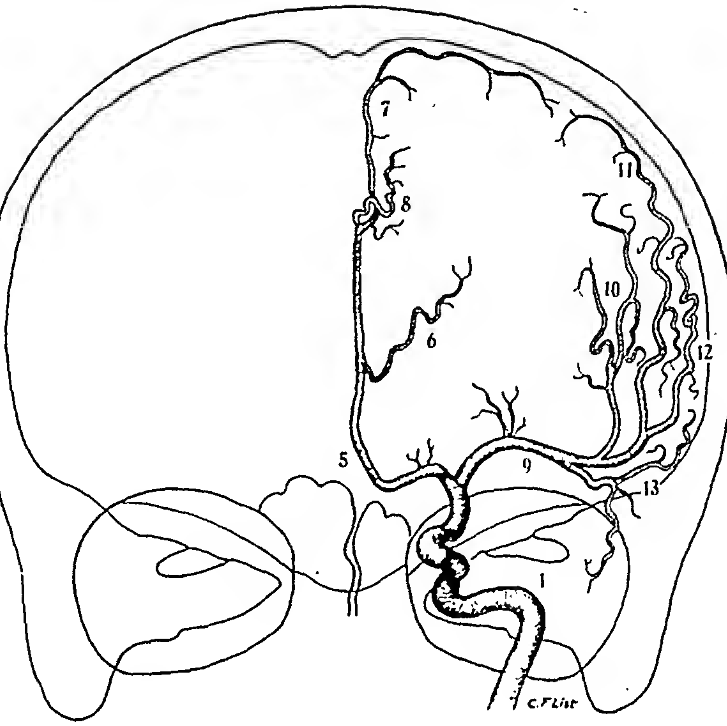
At the University Hospital (Ann Arbor) intracranial angiography has been used systematically since January 1941 in situations where this method of study appeared to offer the likelihood of solving particularly difficult diagnostic problems. In some three years, 127 patients have been subjected to this type of examination. In the bulk of these the carotid system was injected; vertebral arteriography was used in six instances only.

ANATOMICAL CONSIDERATIONS

If the vessels which supply blood to the brain are to be used as a system of landmarks, by means of which lesions involving the brain substance can be identified and localized, the observer must be familiar with the intimate anatomical details of the circulatory system of the brain. When, by means of opaque perfusion, these vessels are seen for the first time in roentgenograms of the skulls of living patients, the intricacies and complexities of their arborizations are bewildering. It is necessary to use frontal and lateral projections of the skull or stereoscopic lateral projection to appreciate the fact that the major branches of the internal carotid lie close to the brain surface.

Entering the cranial vault, the internal carotid artery divides into two major divisions, the anterior and middle cerebral arteries, whose zones of distribution are strikingly characteristic. The branches of the anterior cerebral artery supply the medial surface of the hemisphere over its anterior two-thirds. The middle cerebral artery courses lateralward along the sylvian fissure to the convex surface of the cerebrum. The medial and under surfaces of the temporal and occipital lobes receive blood from the posterior cerebral artery, which arises from the vertebral system. The brain stem and the cerebellum are exclusively supplied by the vertebral arteries. It is obvious that injections of the internal carotid are useful when supratentorial structures are to be examined, whereas angiographic exploration of the posterior fossa necessitates injection of the vertebral system.

When one thinks of the carotid system in terms of sagittal, lateral, and basilar surfaces of the cerebral hemisphere, it becomes considerably easier to use angiography as a graphic method of detecting abnormalities in the brain substance which is surrounded by this vascular network (Figs. 1, 2, 3, 4). Sizable space-occupying masses may displace or distort the vessels which extend over one or all of these surfaces. Alterations of the course, location, or the caliber of particular vessels can be translated in terms of specific neurological structures to localize the causative lesion. For purposes of reference, a detailed anatomical description of the subdivisions of



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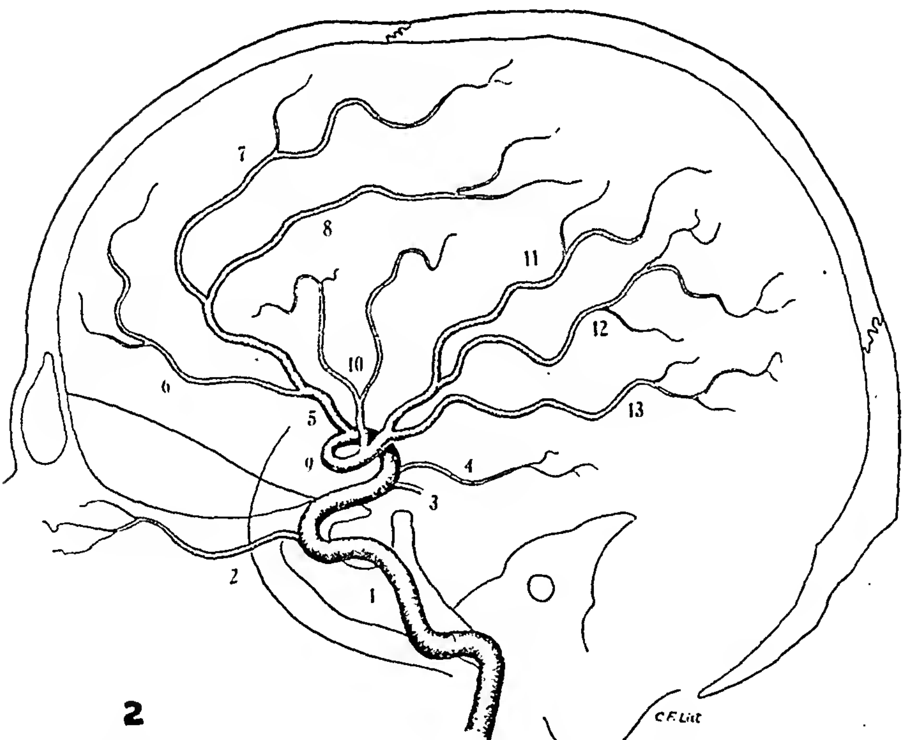

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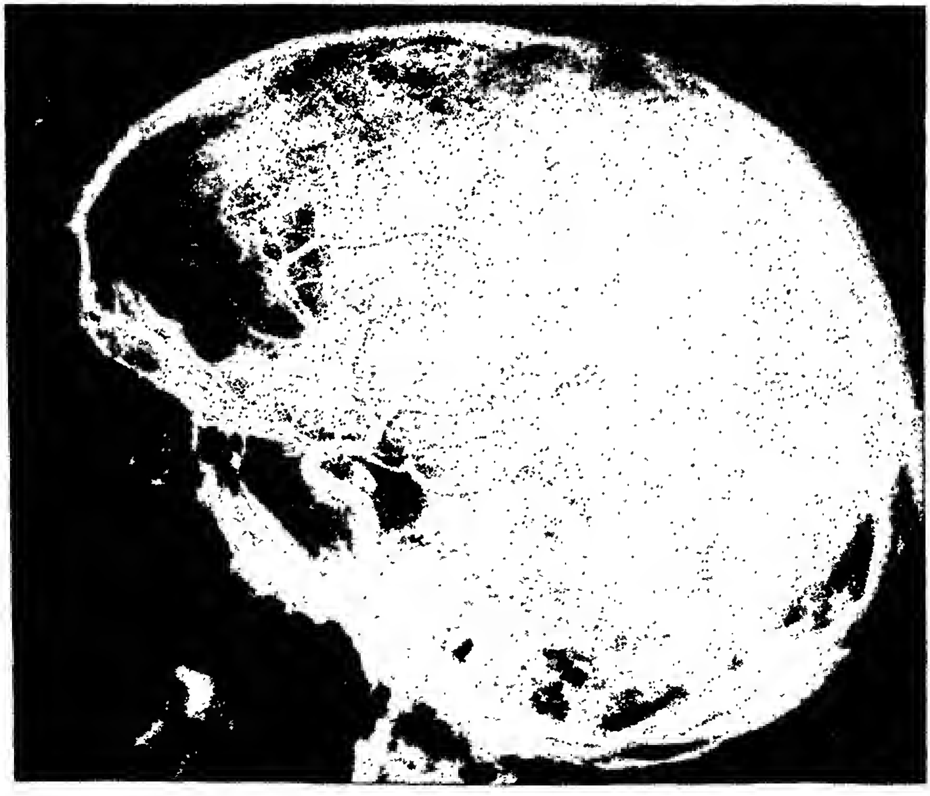
Figs. 1 and 2. Schematic drawings of normal arteriograms of the internal carotid artery (1. Anteroposterior projection. 2. Lateral projection).
1. Internal carotid artery. 2. Ophthalmic artery. 3. Posterior communicating artery. 4. Anterior choroidal artery. 5. Anterior cerebral artery. 6. Frontopolar artery. 7. Callosomarginal artery. 8. Pericallosal artery. 9. Middle cerebral artery. 10. Ascending frontoparietal artery. 11. Posterior parietal artery. 12. Angular artery. 13. Posterior temporal artery.



Figs. 3 and 4. Carotid arteriograms in anteroposterior (above) and lateral (below) projections.

The bilateral anteroposterior arteriogram was obtained by simultaneous injection of both internal carotids. Except for moderate lateral displacement of the sylvian group, due to internal hydrocephalus, the picture is not grossly abnormal. Note that the anterior communicant artery, connecting both anterior cerebrals, is very short.

In the lateral view the posterior communicant and posterior cerebral arteries are plainly visible, an anatomical variation occurring in 15 per cent of all cases.

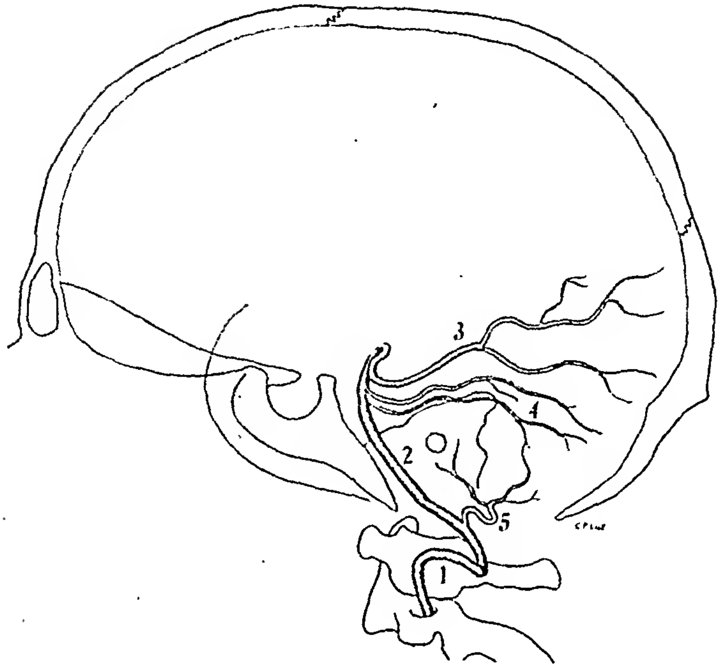


Fig. 5. Schematic drawing of a normal vertebral arteriogram in lateral projection. 1. Vertebral artery. 2. Basilar artery. 3. Posterior cerebral artery. 4. Superior cerebellar artery. 5. Posterior inferior cerebellar artery.

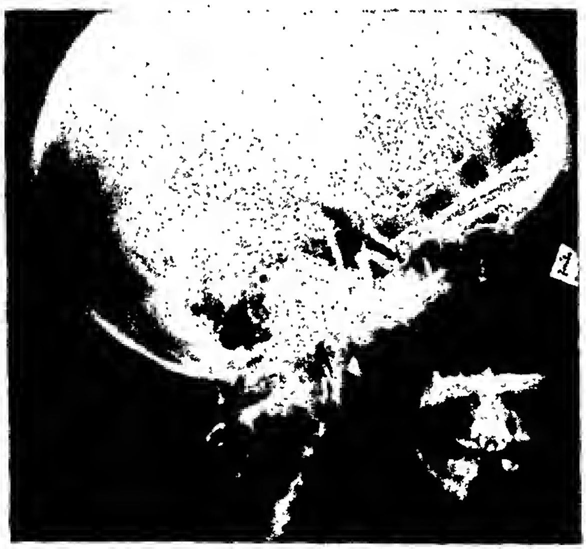


Fig. 6. Normal vertebral arteriogram in lateral projection. The picture was obtained by retrograde injection into the subclavian artery. Due to overflow, the contrast medium has also filled the carotid system. Faint gas shadows are visible from previous ventriculography.

the internal carotid, stressing relationships of practical importance in angiographic diagnosis is appended (Anatomical Notes, A).

Angiography is commonly limited to the study of supratentorial lesions because the technical procedure is somewhat simpler and because results are more satisfactory than in the case of posterior fossa lesions. It is important, however, to be prepared

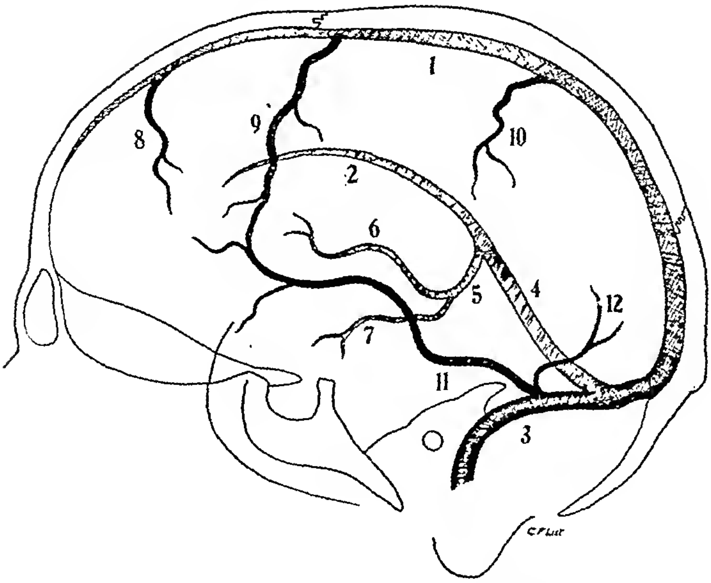


Fig. 7. Schematic drawing of normal venogram in lateral projection, obtained by carotid injection. Superficial veins are shaded more darkly than the sinuses and deep veins.
1. Superior sagittal sinus. 2. Inferior sagittal sinus. 3. Transverse sinus. 4. Straight sinus. 5. Great cerebral vein of Galen. 6. Internal cerebral vein. 7. Basal vein of Rosenthal. 8. Frontal ascending vein. 9. Rolandic vein of Trolard. 10. Parietal ascending vein. 11. Communicating temporal vein of Labbé. 12. Descending temporo-occipital vein.

Fig. 8. Normal venogram in lateral projection obtained by carotid injection. The sinuses are only incompletely filled. A large superficial sylvian vein is visible at the anterior part of the temporal lobe.

to examine the structures beneath the tentorium and for that reason a description of the vertebral system (Figs. 5 and 6) is also appended (Anatomical Notes, B).

Opaque material, distributed by the arteries, is reaccumulated by the cerebral veins, which can be demonstrated in properly timed roentgenograms. Some

familiarity with the anatomy of the venous system is necessary if one is to employ venograms for purposes of accurate diagnosis (Figs. 7 and 8). Here again the general scheme may be described in simple terms. Venous channels within the cranial vault consist of three systems—superficial veins, deep veins, and venous sinuses. Blood from the brain surface is collected by the superficial vessels and by them transmitted to the superior sagittal and lateral sinuses. Blood from the basal ganglia is collected by the deep cerebral veins which lead to the straight sinus. A detailed description of the intracranial venous system is presented below (Anatomical Notes, C).

ANATOMICAL NOTES

A. *Carotid Arteriogram*

The internal carotid artery enters the skull through the carotid canal at the tip of the petrous apex. It passes through the cavernous sinus and, after penetration of the dura, terminates by bifurcation into the anterior and middle cerebral arteries. According to Egas Moniz, the curved intracranial portion of the internal carotid, also called the carotid siphon, forms a simple S-curve (31 per cent), a double S-curve (39 per cent), or a transitional form (30 per cent). The first large intracranial branch, visible in most carotid arteriograms, is the ophthalmic artery. It extends forward from the internal carotid just below the level of the anterior clinoid and enters the orbit through the optic foramen. The next direct branch, the posterior communicating artery, is seldom demonstrated, but in 15 per cent of all cases is so large that the posterior cerebral artery can be considered as arising from the internal carotid. The last branch of the internal carotid before its bifurcation is the anterior choroidal artery, a small yet fairly constant vessel. It passes backward between the medial surface of the temporal lobe and the cerebral peduncle along the optic tract to end in the glomus choroideus of the lateral ventricle.

The middle cerebral artery first courses lateralward in the sylvian fissure, giving off small branches to the basal ganglia, and then turns backward and upward on the surface of the insula, where it gives off several small vertically ascending branches, the largest of which supplies the lower frontoparietal (rolandic) area and has roughly the configuration of the Greek letter ψ. The terminal three branches of the middle cerebral artery, which course diagonally backward and upward in the sylvian fissure, are the posterior parietal artery supplying the convexity of the parietal lobe; the angular (*pli courbé*) branch supplying the angular gyrus and parieto-occipital convexity; and the posterior temporal artery supplying the posterior and superior portions of the temporal lobe. Collectively the last three branches are known as the middle cerebral or sylvian group.

The anterior cerebral artery passes forward and medialward to the longitudinal fissure. It then curves around the genu of the corpus callosum, giving off the frontopolar branch, which passes forward on the medial surface of the cerebral hemisphere toward the frontal pole. The anterior cerebral artery finally turns backward along the medial surface of the cerebral hemisphere and divides into pericallosal and callosomarginal branches, which extend posteriorly.

B. *Vertebral Arteriogram*

The vertebral artery winds behind the superior process of the atlas and, after entering the skull through the foramen magnum, passes upward and medially in close contact with the base of the posterior cranial fossa and ventral surface of the medulla. Its first intracranial branch is the posterior inferior cerebellar artery, which supplies the ventrolateral portion of the cerebellum and medulla. At the pontomedullary junction, the vertebral artery joins the vessel of the opposite side to form the basilar artery, which lies in the mid-line between the clivus and the pons and ends in the interpeduncular space. The basilar artery gives off small pontine branches bilaterally, among them the anterior inferior cerebellar arteries and the superior cerebellar arteries which supply the dorsal surface of the cerebellum and dorsal portion of the midbrain. The basilar artery terminates by dividing into the two posterior cerebral arteries, which are the only supratentorial branches of the vertebral system. Each posterior cerebral artery winds around the cerebral peduncle and, following the basilar surface of the temporal and occipital lobes, courses toward the occipital pole and typically divides into two large terminal branches. The posterior communicating artery is not demonstrated by vertebral arteriography, but, as mentioned before, when this vessel is large it may be shown with the posterior cerebral artery by carotid injection.

C. *Venogram Obtained by Carotid Injection*

Intracranial venous channels can be divided into three systems—superficial cerebral veins, deep cerebral veins, and venous sinuses. The superficial cerebral veins collect blood from the cortex and empty mainly into the superior sagittal and lateral sinuses. There is a variable number of roughly parallel frontal, parietal, and occipital cortical veins which follow the sulci of the brain to the superior sagittal sinus. One of the largest of these is the great anastomotic vein of Trolard, which is located in the posterior frontal (rolandic) area. In the region of the temporal lobe the superior sylvian vein continues into the posterior anastomotic vein of

Labbé, which passes posteriorly and inferiorly across the temporal lobe to the lateral sinus. This sinus also receives some smaller tributaries from the inferior surface of the temporal lobe.

The deep cerebral veins drain the basal ganglia. The two internal cerebral veins are located in the tela choroidea on the dorsal surface of each thalamus. They receive the basal veins of Rosenthal, which come from the base of the brain around the cerebral peduncles. The junction of the internal cerebral veins forms the great cerebral vein of Galen, which is median in position, very short, and terminates in the straight sinus.

The superior sagittal sinus is located in the superior portion of the falx cerebri and ends in the confluens sinuum by joining in the straight and lateral sinuses. The smaller inferior sagittal sinus is located in the inferior edges of the falx; it forms the straight sinus by junction with the vein of Galen. Egas Moniz has pointed out that the straight sinus is a direct continuation of the inferior sagittal sinus and that the vein of Galen joins it at an acute angle. This is contradictory to older anatomical teachings based on studies of cadavers. The posterior portion of the inferior sagittal sinus and the vein of Galen outline the splenium of the corpus callosum. The *venogram* obtained by *vertebral injection* demonstrates numerous superficial cerebellar veins. Most of them collect on the dorsal surface of the cerebellum and drain into the transverse sinus or into the straight sinus forming a vascular plexus in the pineal area.

PHYSIOLOGICAL CONSIDERATIONS

Normally it requires about four seconds for blood to pass from the carotid artery by way of the various cerebral vessels and their capillary networks to the large intracranial venous sinuses. By proper timing of injection and exposure, either the arterial or the venous phase of the cerebral circulation can be recorded without difficulty. The arterial phase lasts throughout the first second following injection. The capillary phase, recognizable in angiograms by generalized increase in soft-tissue density, is very brief, for within three seconds after injection the veins begin to fill, and lastly the venous sinuses. Blood from the vertebral arteries reaches the venous sinuses after a slightly longer period.

If stereoscopic filming is to be done, time relations must be exactly duplicated during two separate injections of opaque material. By means of dexterous teamwork perfected by frequent practice, it is possible to produce two pairs of stereoscopic films representing an arteriogram and a venogram of the same patient with but two injections of contrast material.

Increased intracranial pressure and widespread venous stasis prolong intracranial circulation time. Partial vascular occlusion, aneurysm, and certain neoplasms may produce localized slowing of blood flow. In order to obtain maximum contrast between injected blood vessels and normally translucent surrounding brain tissue, conditions which lead to excessive dilution of the opaque mass with normal blood are to be avoided. Opaque material must be injected briskly, being added to the normal inflow of blood from the carotid on the side being studied. This is necessary in order to prevent the anterior cerebral artery from being flooded from the contralateral side by way of the anterior communicating artery. When this does occur, some of the branches which one desires to observe may be filled with normal blood instead of blood which has been mixed with opaque material.

TECHNIC

Surgical Procedures

Carotid Angiography: Local anesthesia is used. Preoperative anticonvulsive medication is desirable in the case of patients who are known to have had convulsions.

The carotid bifurcation is exposed by means of a 5- to 8-cm. incision parallel to the sternomastoid muscle (Fig. 9, 1). After incision of skin, subcutaneous tissue, and platysma, and after lateral retraction of the sternomastoid muscle, the sheath of the great vessels is entered. In retracting the internal jugular vein, one or more deep facial veins are sometimes in the way and may have to be retracted or, rarely, ligated and cut. Segments of the common, internal, and external carotid arteries are dissected free and stripped of adventitia. Untoward systemic reactions resulting from the carotid sinus reflex are avoided by local injection of procaine. A thin rubber strip is placed around the common carotid,

and another around the beginning of the external carotid. The common and internal carotid arteries are elevated with pledgets of cotton. The patient is now transferred to the x-ray table. For lateral projection, the head is turned toward the unoperated side; the side to be injected is farthest from the film. Immobilization of head and shoulders is important.

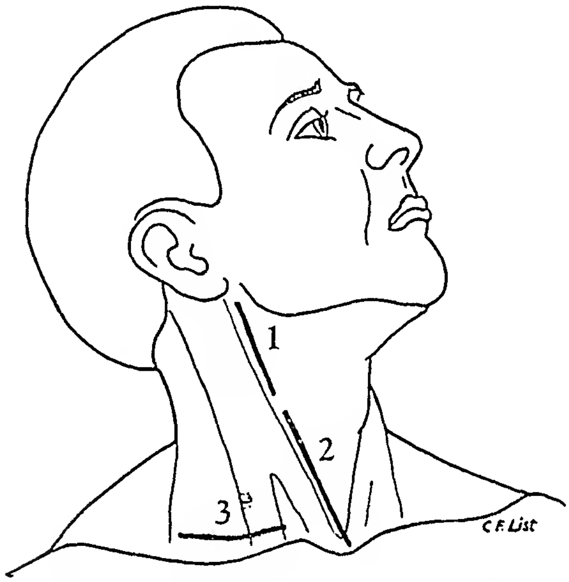


Fig. 9. Schematic drawing to show the surgical incisions used for arteriography. 1. For carotid injection. 2. For direct vertebral injection. 3. For indirect vertebral injection (retrograde subclavian injection).

Injection equipment consists of three 10-c.c. and three 20-c.c. Luer syringes, an 18- or 19-gauge needle of medium bevel, 3 to 4 cm. in length, and a 10-cm. length of pliable though non-collapsible rubber tubing fitted on either end with adaptors. Syringes, adaptors, and tubing must be well tested in advance; they must not fail when used at high speed under considerable pressure.

The common carotid is elevated, but not strangulated, by means of the rubber strip. The external carotid is pulled upward slightly and is purposely strangulated by twisting its rubber strip. The needle-tube-syringe combination is filled with the injection material. The needle puncture is made in the internal carotid at its origin or in the common carotid just proximal to the bifurcation. In the latter case, the

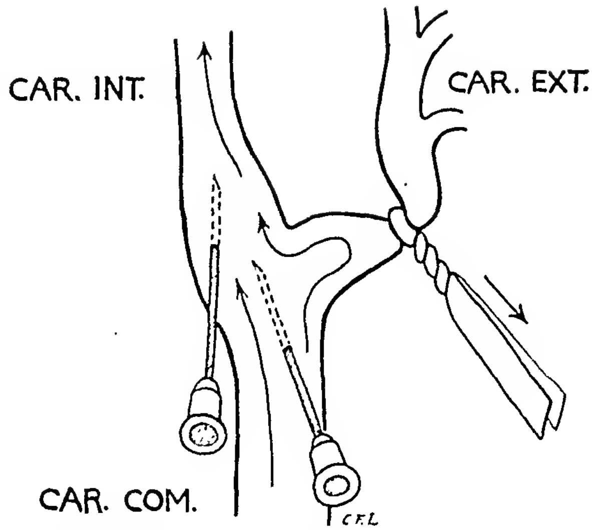


Fig. 10. Schematic drawing to show the technic of carotid arteriography. The external carotid is strangulated and the injection is made either into the internal carotid or common carotid below the bifurcation.

point of the needle is directed toward the orifice of the internal carotid (Fig. 10). If the patient's neck is short, or if the bifurcation is highly placed, injection by way of the common carotid is the method of choice. Great care is taken to avoid multiple arterial punctures. When the needle is in proper position, the arterial blood pressure will push back the plunger of the syringe and the needle will be gripped by the elasticity of the arterial wall so that it is not necessary to hold the needle firmly. Ordinarily three injections are made, two to obtain stereoscopic lateral views, and the third for a single anteroposterior projection. A total of five films are exposed. Each injection consists of 10 c.c. (8 to 12 c.c. may be used). The opaque material is forced into the artery as rapidly as possible. When the first injection is two-thirds complete, the signal is called for beginning of the x-ray exposure. As soon as the film can be changed, usually about three seconds after the injection is completed, a second exposure is made. This is intended to record venous return.

Without disturbing the needle and tubing, the empty syringe is replaced by a 20-c.c. syringe containing Ri[illegible]'s solution, and the rubber tubing [illegible] re flushed to [illegible] y

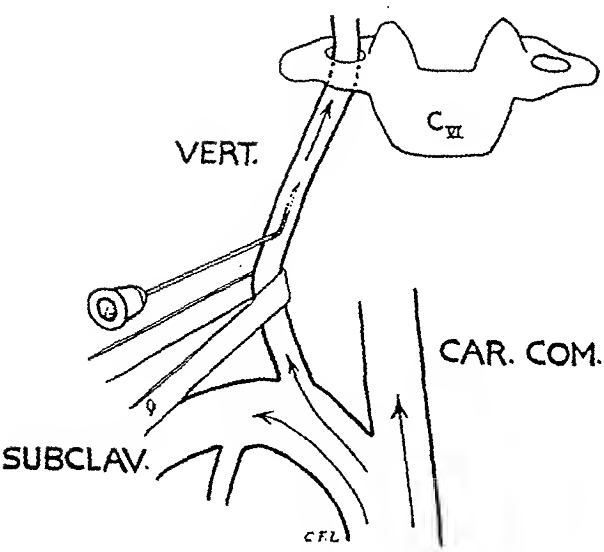


Fig. 11. Schematic drawing to show the technic of direct vertebral arteriography.

tube is then shifted for stereoscopy and a second injection is performed in an identical manner. Following the second injection, the tubing and needle are flushed continuously with Ringer's solution until the head is rotated to the anteroposterior position.

To expose the skull in this direction, the x-ray tube is angled so that its beam will pass through a plane which includes the external auditory meatus and a point in the mid-line of the forehead 5 cm. above the glabella. A third injection is made and, due to the longer exposure time used for this projection, the signal for starting the x-ray exposure is given immediately after the injection is begun. No venogram is made in this instance.

Strangulation of the external carotid is then discontinued, the needle is withdrawn, and hemostasis is accomplished by firm packing and some digital pressure. Cotton packs and rubber bands are removed. When all bleeding has stopped, the wound is thoroughly washed with warm Ringer's solution and is closed in layers. A small sandbag is placed over the dressing for about eight hours to prevent after-bleeding.

Vertebral Angiography: The technical difficulties of injecting the vertebral system are considerable because of the relative inaccessibility of the vertebral artery. Two methods are practicable. The first, elaborated by Sjöquist and King, consists of direct puncture of the vertebral artery before it enters the transverse process of the sixth cervical vertebra. Incision is made in the lower neck along the anterior border of the sternomastoid muscle at the level of the thyroid gland (Fig. 9, 2). The omohyoid muscle is exposed and divided; the sternomastoid muscle is retracted laterally. The thyroid gland is retracted medially after the sheath of the great vessels has been dissected away from its capsule. The inferior thyroid artery is retracted downward. After exposure of the deep prevertebral muscles, the transverse process of the sixth cervical vertebra is palpated. Pulsations of the vertebral artery can often be felt just below this transverse process. The deep neck muscles are then split to permit isolation of the artery for a length of about 2 cm. after being surrounded with a strip of rubber tape. It may be necessary to clip or coagulate the vertebral vein. Because of the deep position and relatively small size of the vertebral artery, its injection requires the use of a 20-gauge needle about 6 cm. in length angled 8 mm. from its point (Fig. 11). Because of the slowness of blood flow in the vertebral system, x-ray exposure is delayed for one-half to one second after the completion of injection. Eight to 10 c.c. of contrast material are sufficient.

The second method, advocated by Egas Moniz, accomplishes vertebral perfusion indirectly by retrograde injection into the subclavian artery. A transverse incision is made 2 cm. above and parallel to the clavicle, between the outer border of the sternomastoid and the trapezius (Fig. 9, 3). The external jugular vein may have to be ligated and divided. The sternomastoid muscle is retracted medially, and for good exposure its lateral margin may have to be cut. The phrenic nerve is identified and the scalenus anterior is divided. Rubber strips are placed about the subclavian artery and the thyreocervical axis. A

straight 18-gauge needle is inserted into the subclavian against the direction of blood flow and, after complete strangulation distal to the point of puncture, 10 to 15 c.c. of opaque material are injected (Fig. 12). Partial escape of the opaque material into the carotid system may occur.

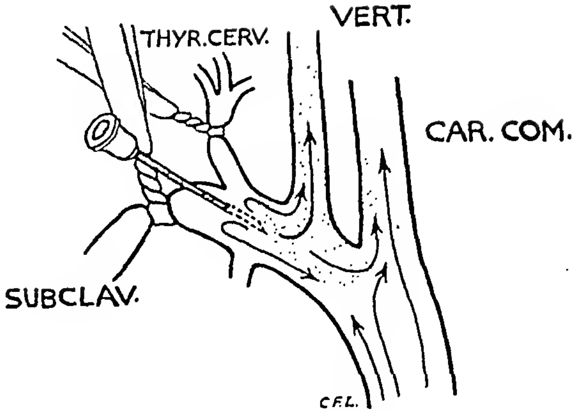


Fig. 12. Schematic drawing to show the technic of indirect vertebral arteriography. After strangulation of the subclavian artery (and thyreocervical axis), the contrast medium is injected against the current of blood into the subclavian artery. Most of the contrast medium is forced into the vertebral artery; some may flow over into the common carotid.

X-Ray Procedure

The x-ray procedure requires no specialized apparatus. It is necessary to use a tube of relatively fine focus and a moving grid to produce roentgenograms of satisfactory quality. The advantages offered by stable, well calibrated, heavy-duty equipment easily offset those provided by mobile apparatus which can be wheeled into the operating room. The equipment we have used consists of a line-focus, shock-proof tube (effective focal spot of 2.3 mm., energized by a fully rectified transformer) operating through a flat, radial type, moving Potter-Bucky diaphragm at a target-film distance of 36 inches. The tube and diaphragm are carried on a head table of the type developed at the University of Chicago (16), which is designed to permit accurate positioning and exact duplication of particular projections. This head table, though extremely convenient, is not indispensable. For lateral projections, exposures of 1.5 seconds are made at 20 ma. and 75 kv. For anteroposterior projections, kilovoltage is raised to 85 and time is increased to 3 seconds.

Our experience has shown that split-second exposures are actually less desirable than exposures as long as 1.5 seconds. The still longer exposures we have found necessary for anteroposterior projection are not desirable, but, lacking a rotating anode tube, we have been unwilling to sacrifice fine definition by employing a focal spot larger than 2.3 mm.

Stereoscopic filming is highly desirable in order to permit accurate identification of overlapping vessels as seen in lateral projection. The anteroposterior projection need not be stereoscopic, but no carotid angiogram can be considered satisfactory without a single exposure in this axis. It is important that the bifurcation of the carotid be projected above the orbits and the frontal sinuses.

By means of various types of equipment specially designed for intracranial angiography, the human factor may be largely eliminated in the spacing and timing of exposures (17, 18). It is true, however, that satisfactory results can be obtained with the apparatus already available in most hospitals.

Selection of Contrast Media

If one could discover a water-miscible substance of extreme radiopacity, entirely non-toxic and non-irritating, which, following injection, would be rapidly and completely excreted from the body, that substance would be an ideal contrast medium for intracranial angiography. While none of the materials at present available is able to meet these exacting specifications, diodrast and thorotrast are in common use.

Diodrast, which is promptly and completely excreted, produces satisfactory vessel shadows when concentrations of 35 to 60 per cent are used, but the local irritation which this material produces is troublesome and sometimes frankly alarming, especially when convulsions occur (12). Extravascular leakage produces local inflammation. In our opinion, the unde-

TABLE I: RADIOACTIVITY DETERMINATIONS

Substance	Wt. of Sample (grams)	Activity (microcuries)	Activity (mc./gram)	Computed Total Activity 44 c.c. thorotrast	Computed Total Activity 30 c.c. thorotrast
Uranium standard	0.1	0.10	1.0	...	...
Thorotrast, 10 c.c. (evaporated)	4.26	0.68	0.159	2.97	2.03
Vertebra (ashed)	1.20	0.0028	0.0023	...	...
Liver (ashed)	0.068	0.0106	0.156	2.58*	1.76*
Spleen (ashed)	0.060	0.0166	0.277	0.19†	0.13†

Total measurable radioactivity, liver and spleen, after 44 c.c. thorotrast........................2.77 microcuries
Total measurable radioactivity, liver and spleen, after 30 c.c. thorotrast........................1.89 microcuries

* Wet weight of liver, 1,510 grams. Total ash, 16.61 grams.
† Wet weight of spleen, 140 grams. Total ash, 0.70 gram.

sirable properties of the substance outweigh its virtues as a contrast material in this particular field.

Thorotrast, 25 per cent thorium dioxide in colloidal suspension, is water-miscible, highly opaque to x-rays, and virtually non-irritating. Once injected, however, it is excreted very slowly and in this particular it fails to meet ideal specifications. Because of its measurable and relatively long-life radioactivity, greatly prolonged retention of thorotrast in the reticulo-endothelial system has been a source of considerable concern to several authors (9, 19). The intensity of the beta and gamma radiation from this material is probably entirely too slight to be of real importance, but in samples of 25 c.c. thorotrast is said to emit alpha particles within minimum-maximum limits equivalent to 0.5 to 1.0 microgram of radium (20). The lowest recorded rate of activity observed in the bodies of persons with demonstrable radium poisoning is that which is equivalent to 2.0 micrograms of the element (9).

One of our patients, who had an inoperable brain tumor, died several weeks after angiographic examination. Blocks of liver, spleen, and bone were obtained at autopsy. One month after death and approximately two months after angiography, these tissues were ashed, and weighed samples were submitted to Prof. James M. Cork of the Department of Physics of the University of Michigan for ionization measurements. The results of his analysis are shown in Table I. One of the injections necessary to prepare a complete set of angiograms was repeated because of inaccurate timing of the x-ray exposure, bringing the total amount of thorotrast used in this particular case to 44 c.c., whereas it should not be necessary to exceed 30 c.c. Figures in Table I show that 10 c.c. of a thorotrast sample selected at random showed a rate of radioactivity above the range reported by other authors. The ionization measurements indicate that the bulk of the thorotrast had been deposited in the liver and spleen at the time of the patient's death; that the total radioactivity of these two organs was, in this case, in excess of the lowest recorded level in cases of radium poisoning. By adjusting these figures to conform to the situation which would have obtained if the amount of thorotrast injected had been held to the recommended limit of 30 c.c., it is found that the total measurable ionization in spleen and liver would have been 1.89 microcuries, definitely below the lowest level which has been observed in radium poisoning. Contact exposures of non-screen x-ray film to samples of the spleen ash for seventeen hours produced clearly recognizable blackening on development. Blackening was very intense for longer exposures. Much fainter photographic changes were produced in the case of ashed liver, while the radioactivity in bone ash was too weak to be clearly demonstrated by the photographic method.

The potentiality of long delayed radiation damage following the intravascular injection of thorotrast in the amounts required for intracranial angiography is admittedly worrisome. In our experience the blandness of this contrast material, in

so far as immediate effects are concerned, has been well established in comparison with 35 per cent diodrast. This is a most commendable characteristic. During the three and one-half years we have been using thorotrast, none of our patients who have survived their intracranial lesions has shown any detectable signs of ill effect due to stored radioactive substances. The possibility of such undesirable effects presenting themselves at some future time cannot be denied but Egas Moniz (21), whose experience covers a period of thirteen years, has recently written us that he has never observed any suggestion of untoward effect chargeable to thorotrast.

Another contrast substance, colloidal tri-iodo-ethyl-stearate, described by Degkwitz (22), is reported by Häussler (23), to possess the desirable properties of excellent radiopacity, compatibility, and of complete elimination. This substance cannot be obtained in this country and our efforts to have it manufactured have thus far been fruitless.

DISCUSSION

When the indications for its use are clear, intracranial angiography may be employed without danger to the patient if certain conditions are observed. In our series of 127 patients examined by this method, there has been no fatality attributable to the procedure. It is manifestly unwise to inject any material into the circulation of the brain in cases of extreme arterial hypertension, far advanced arteriosclerosis acute intracerebral or subarachnoid hemorrhage, recent thrombosis, or embolism of cerebral vessels. Even in the absence of such contraindications, one may occasionally encounter transient hemiparesis, hemiparesthesia, aphasia, convulsive manifestations, or temporary accentuation of presenting neurological signs. Untoward effects such as these occurred in less than 3 per cent of our patients, and in no instance did the undesirable effects persist. Similar symptoms are fully as common after pneumographic procedures. Actually angiography is better tolerated than ventriculography in certain cases of expanding lesions associated with high intracranial pressure, because intracranial hydrodynamics are not materially altered.

Obviously, angiographic methods should be used with discretion. Preliminary lateralization of the lesion is essential if one is to know which side to inject. Carotid injection serves no good purpose if the lesion lies in the posterior fossa.

Transcutaneous arterial injection, advocated by some authors (10), does not appeal to us. We prefer the direct surgical approach, which eliminates the likelihood of extravascular leakage and inadvertent dislodgment of the needle with consequent danger of uncontrolled bleeding. Egas Moniz uses the simple surgical procedure of exposing the common carotid at the base of the neck. We feel that it is only slightly more difficult to prepare the internal carotid for injection and that this approach holds the total amount of contrast material needed at a minimum and obviates annoying shadows cast by branches of the external carotid.

SUMMARY

1. The opacification of intracranial vessels for the purpose of accurately localizing lesions within the cranium is a practicable procedure.

2. Intracranial angiography demands the employment of an exacting technic combining surgical and roentgenographic procedures.

3. Despite its undesirable property of long half-life radioactivity, thorotrast in amounts not exceeding 25 to 30 c.c. is the most satisfactory contrast material at present available for intracranial angiography.

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Roentgen Observations on Primary Atypical Pneumonia[1]

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APPROXIMATELY ten years ago scattered reports began to appear in the foreign literature concerning certain lobular pneumonias of atypical character and distribution associated with unusual clinical findings. Later reports appearing in the American literature (Bowen, Allen, Reimann, Goodpasture and others) established the disease as a new clinical entity of characteristic symptomatology, course, and laboratory findings.

Excellent discussions of the clinical and roentgen findings in this disease are to be found in the recent medical literature, but certain features, it is believed, have either escaped notice or have not received the attention they deserve.

The observations which are the subject of this paper are derived from a study of approximately 1,500 pneumonia patients admitted to the AAF Regional Station Hospital of the Santa Ana Army Air Base over a period of two years. Of these, approximately 1,200, or 80 per cent, have been clinically classified as suffering from "primary atypical pneumonia." All have had interval roentgen studies. For the purpose of accurate analysis, the roentgen findings in 300 of these cases have been carefully tabulated.

CLINICAL ASPECTS

One of the most striking features of primary atypical pneumonia, at least to the radiologist, is the relatively mild clinical course of the disease as compared with the amount of infiltration shown on corresponding chest films. In one series of 26,448 routine 4 × 10-inch photoroentgen examinations of the chest on supposedly healthy young adults applying for air crew training, 153, or 0.58 per cent, showed varying degrees of infiltration, usually small in amount, but occasionally occupying as much as one-fourth of a lung field. The findings were confirmed by recheck 14 × 17-inch films, and the subsequent clinical classification was almost invariably primary atypical pneumonia. When questioned, many of these men reported no symptoms of any kind. Others complained only of a recent "cold" or "cough" or of feeling weak, easily fatigued, or "under par."

Patients admitted to the hospital because of a more acute or severe illness complained primarily of fever and chills, cough, general malaise, weakness, and various aches and pains. The onset was usually moderately acute over a period of one to three days. Cough, either dry or productive of slight mucoid sputum, was present in most cases, and was often the outstanding symptom, complained of bitterly because of its persistent, irritating character. A sensation of extreme weakness, fatigue, or exhaustion was one of the most pronounced and also one of the commonest findings. In mild cases, it was sometimes the only symptom. There was often accompanying moderately severe and persistent headache, general aching, or both. Sore throat was frequently present but was seldom severe or the presenting symptom. Chills or chilly sensations and profuse perspiration were encountered commonly, especially in the early stages of the disease. Nasal obstruction or discharge was also observed in some cases. Pain in the chest, which was an occasional complaint, was seldom pleuritic in character but was usually of a dull or burning central type.

The incidence of these various findings in a sample group of 40 cases was as follows:

Cough (dry or productive of slight sputum)	75%
General malaise, fatigue, weakness	68%
Sore throat (usually mild or moderate)	58%
Headache (usually mild or moderate)	42%
Chills (and "chilly" sensations)	38%

[1] Accepted for publication in October 1944.

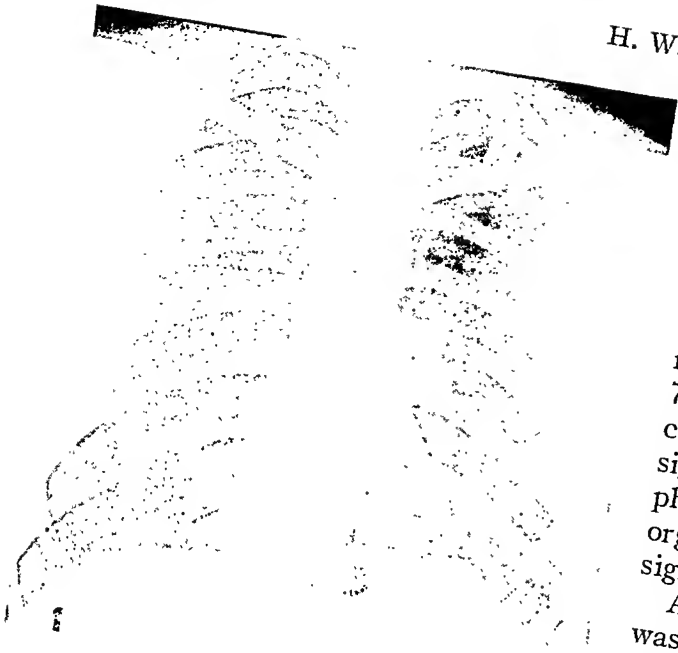


Fig. 1. Primary atypical pneumonia, mediobasal peribronchial type. Complaints: Weakness, fatigue, vertigo, anorexia, cough, initial headache, substernal oppression. Left basal râles. Temperature: 101° two days; 99° two days. WBC: 7,400; neutrophils, 62 per cent. Sputum: Negative for pathogenic organisms.

General aching (including backache)........	25%
Profuse perspiration........................	15%
Nasal obstruction and discharge...........	8%
Nausea and anorexia........................	8%
Pain in chest (usually central type).........	5%

Physical findings were few and inconstant. In general, the patients appeared rather lethargic, apathetic, and not particularly concerned about their illness nor interested in their surroundings. Respiration was quiet and unlabored. The skin was usually warm and moist at the onset, often slightly flushed, occasionally cool, pale, or faintly cyanotic, or was changeable from day to day, particularly over the extremities, giving the impression of vasomotor instability. Inspection of the throat commonly showed a dry, unedematous erythema of mild to moderate degree. Percussion and auscultation often gave negative findings for the first twenty-four to forty-eight hours, but fine crackling râles could usually be heard over the area of involvement thereafter.

Temperature was of a spiking, irregular type, varying from 99° to 104°, usually over a period of three to six days. In only 8 patients, or 20 per cent of a sample group of 40, was the temperature elevated beyond a week. White blood counts varied from 4,450 to 17,950, with 92 per cent falling between 5,000 and 13,000. Polymorphonuclear leukocytes accounted for less than 75 per cent of white cells in 77 per cent of cases. Smears and cultures of the sputum significantly showed only the normal nasopharyngeal bacterial flora with pathogenic organisms either absent or present in insignificant numbers.

Although the acute phase of the disease was usually brief, the average period of hospitalization was approximately three weeks, often followed by convalescent care for another two to six weeks. One reason for such prolonged hospitalization is found in the persistent asthenia which so commonly follows the disease, often associated with an elevation of the pulse rate and abnormal cardiac response to exercise. An additional reason for prolonged hospitalization and convalescent care is the pronounced tendency to relapse and, in some cases, to the development of new zones of pulmonary infiltration if the patient is returned to duty too soon.

ROENTGEN FINDINGS

The infiltrations radiographically demonstrated in primary atypical pneumonia show great variation as regards extent, character, and duration. It would be difficult, in fact, to establish roentgen criteria for a "typical" case. It is even more difficult, in a given case, to decide from the film alone whether a pneumonic infiltration falls within this category. Certain general statements, however, appear justified. It can be stated, for instance, that pneumonias of this type are rarely lobar in character or distribution; that the majority are localized to the middle or lower lung fields; that they are slow in resolution, usually passing through an intermediate stage of peribronchial infiltration and occasionally shifting from one part of the lung to another; that there are few com-

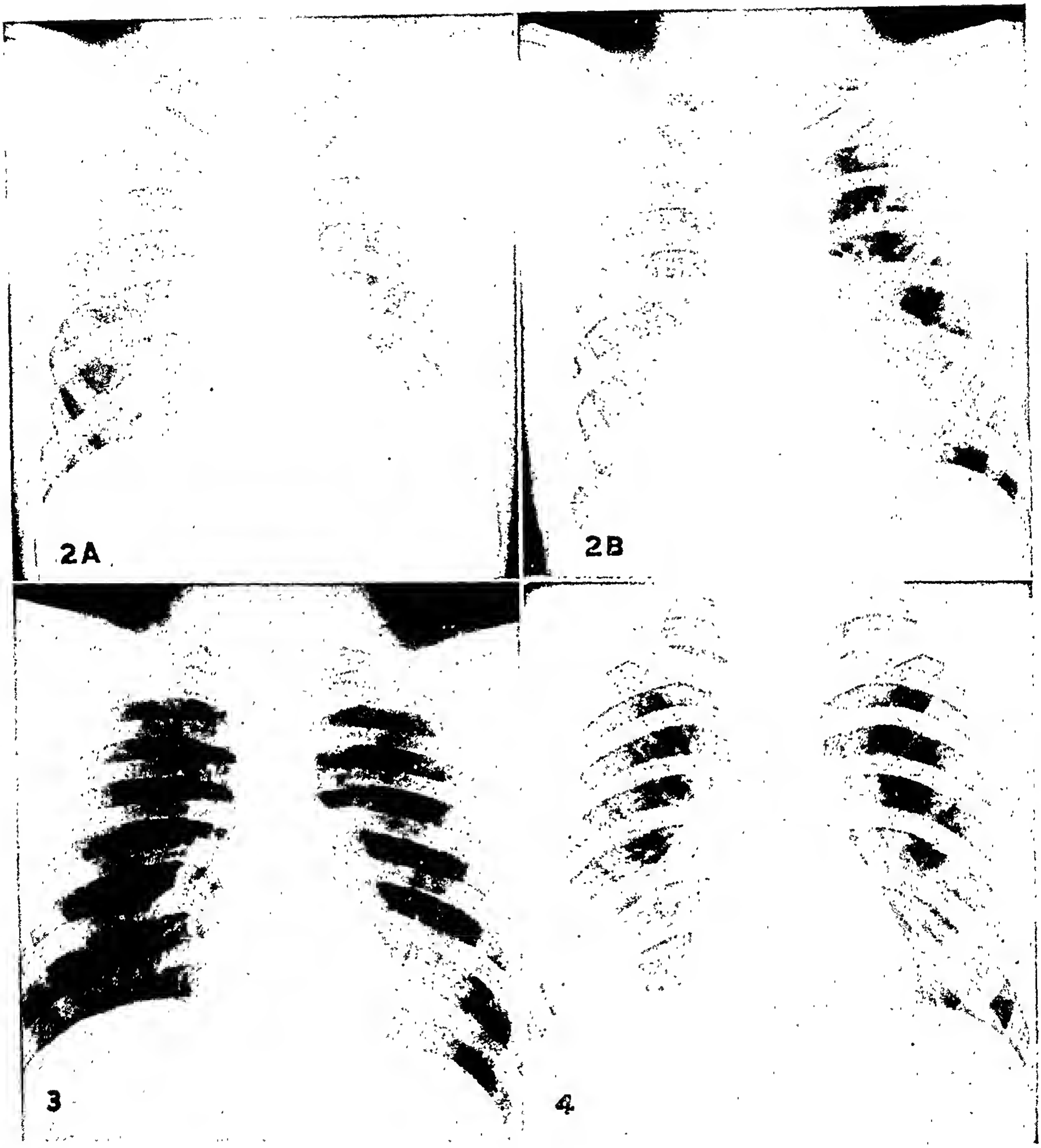


Fig. 2A. Primary atypical pneumonia, local rounded zone of consolidation, left base. Complaints: Cough, fever, general aching, pain in left chest and left shoulder on cough. Friction rub and râles, left base. Temperature 99–100°, four days. WBC: 7,500; neutrophils, 65 per cent. Sputum: Negative.

Fig. 2B. Primary atypical pneumonia, confluent, right mediobasal. Same case as 2A, six weeks later. Temperature normal during interval between development of the basal consolidations on opposite sides. The second consolidation developed when the patient was allowed a three-day pass after apparent recovery from his initial illness. Temperature: 102–104°.

Fig. 3. Primary atypical pneumonia with pneumatocele adjacent to the cardiac apex. Complaints: Chills and fever, slightly sore throat. Physical findings negative. Temperature: 99–102°, five days. WBC: 7,850; neutrophils, 76 per cent. Sputum: Negative. Pulse elevated two weeks after return of temperature to normal: at rest, 84–96; after exercise, 124–140.

Fig. 4. Primary atypical pneumonia, isolated rounded zone of consolidation, right base. Complaints: Weakness and malaise, chills and fever, slightly sore throat, cough. Râles, right base. Temperature: 99–100°, two days; normal to 99°, five days. WBC: 7,800; neutrophils, 69 per cent. Sputum: Negative. Vasomotor instability, cold moist hands, tremor, approximately five weeks.

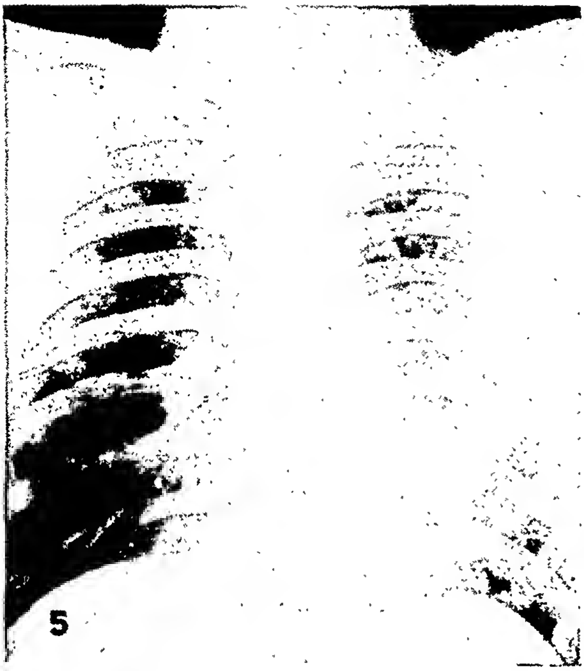


Fig. 5. Primary atypical pneumonia, hilar or central type. Complaints: Fever, aches and pains, slight headache, general malaise, slightly productive cough. Few râles in left axilla. Temperature: 99–100°, five days. WBC: 8,700; neutrophils, 61 per cent. Sputum: Negative.

plications; and that a fatal termination is rare indeed.

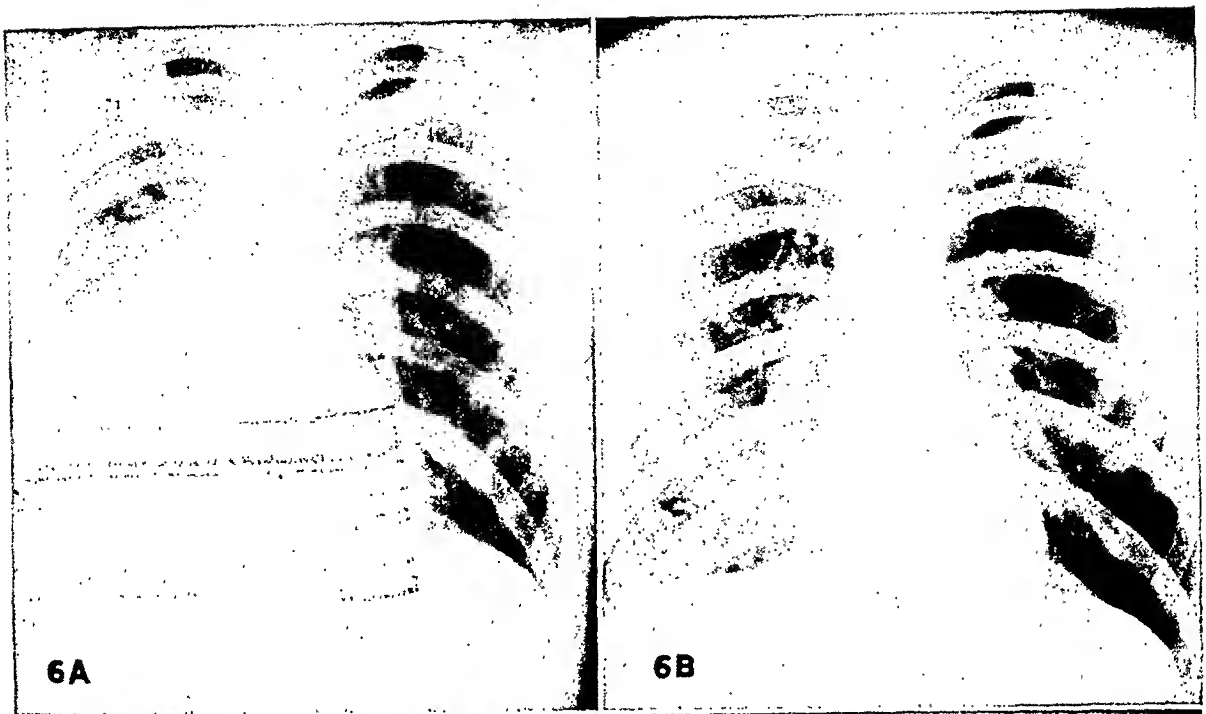
Infiltrations of primary atypical pneumonia fall roughly into two main classes: one, a mediobasal peribronchial type; the other, a more or less confluent type of pneumonic consolidation. Of our sample group of 300 cases in which the roentgen findings were tabulated, 110, or 37 per cent, were of the peribronchial type, while the remaining 190 were classified as the confluent type of pneumonia.

The peribronchial type of infiltration is localized, in the great majority of cases, to the mediobasal portions of the lungs. It varies in extent from a fuzzy thickening of the mediobasal trunks with haziness of intervening tissues to a diffuse patchy or mottled involvement, again closely associated with the basal trunk markings. In general, these cases comprise the clinically milder, more rapidly resolving pneumonias, though infiltration may persist one to three weeks after the temperature returns to normal and the patient feels clinically well. The average time required for clearing in 110 cases was between two and three weeks.

We have two cases with presumptive evidence that bronchiectasis developed following a peribronchial atypical pneumonia. Coughs which initially occurred with the acute phase of the disease in these patients persisted and increased. Previous histories were entirely negative as regards the chest. Lipiodol bronchograms revealed a definite bronchiectasis of mild to moderate degree in each case. Recheck bronchograms taken on one of the patients, however, showed the bronchiectasis to have practically disappeared along with clinical symptoms after a period of approximately four months.

Frank consolidations of the confluent or relatively homogeneous type accounted for 63 per cent of our sample group of 300 cases. Most of the clinically more severe or prolonged cases fall within this group, but many mild cases are also included.

A large majority of the pneumonic infiltrations are found in the middle or lower lung fields. Among the 190 confluent pneumonic cases in our series, the distribution in the lung fields was as follows: right lower, 63; left lower, 76; bilateral lower, 6; hilar and mid-lung, 28; right upper, 15; left upper, 2. The infiltrations vary from a soft homogeneous veil-like haze to a density of moderate grade, approaching, but rarely equalling, that of lobar pneumonia. They frequently assume a rounded shape somewhat denser in the center, fading at the periphery. Occasionally well circumscribed rounded zones of consolidation are encountered which appear almost ball-like in the lung fields. True lobar distribution is seen only rarely; the disease is no respecter of interlobar boundaries. Nor, as a rule, is the infiltration so uniform as in lobar pneumonia, though large confluent cotton-woolly zones are common. Occasionally (2 per cent in our series) central pneumatoceles develop within zones of consolidation, producing cavity-like appearances. Such pneumatoceles disappear as the surrounding pneumonia resolves.



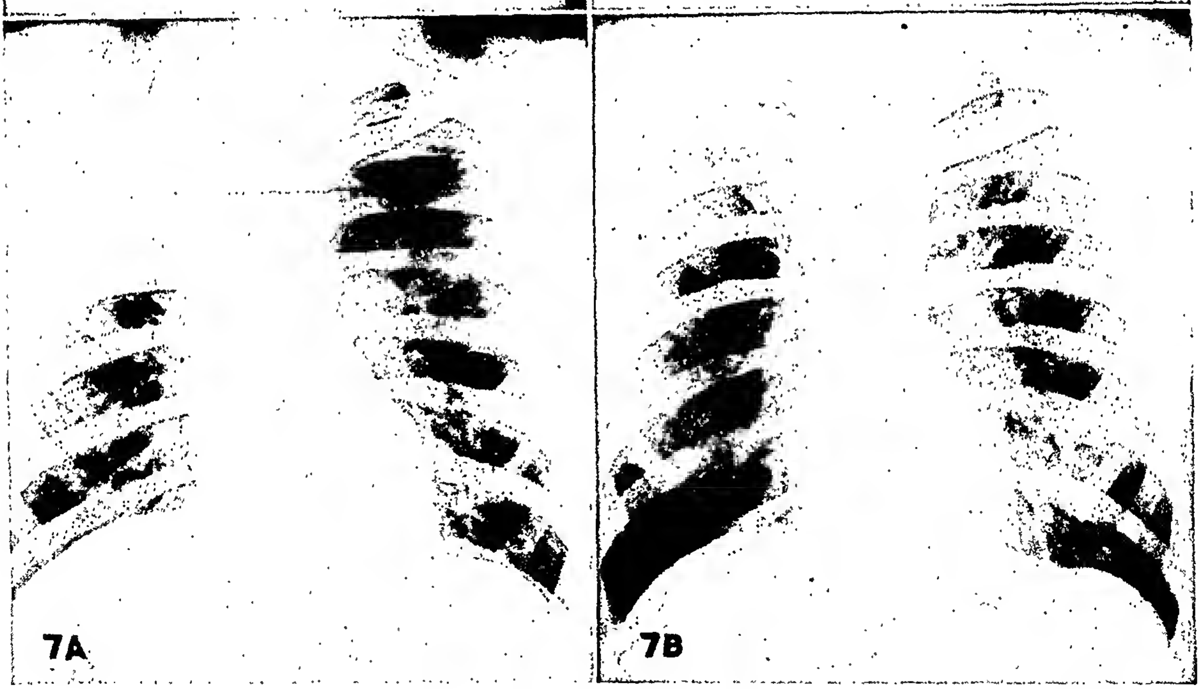


Fig. 6A. Primary atypical pneumonia, extensive, involving primarily right middle and lower lobes. Complaints: Fever, chilly sensations, dry cough, headache. No râles until two days after admission. Temperature: 99–103°, eight days. WBC: 8,750; neutrophils, 65 per cent. Sputum: Negative.

Fig. 6B. Primary atypical pneumonia, in peribronchial stage of resolution. Same case as 6A, ten days later. After an additional two weeks, the lungs had cleared completely.

Fig. 7A. Primary atypical pneumonia involving right upper lobe. Complaints: Cough, substernal pain, headache. Friction rub, right sternal border. Râles not heard until fifth day. Temperature: 100–103°, ten days. WBC: 8,500; neutrophils, 65 per cent. Sputum: Negative.

Fig. 7B. Primary atypical pneumonia in peribronchial stage of resolution. Same case as 7A, one week later. The appearance at this stage is suggestive of pulmonary tuberculosis. The lungs were completely clear after three weeks.

8

Fig. 8. Primary atypical pneumonia, diffuse, finely patchy type. Onset abrupt with severe malaise, chills, cough, moderately sore throat. Patient severely ill; course not affected by sulfa drugs, convalescent serum, or other therapy. Temperature: 100–104°, eighteen days. WBC: 11,650; neutrophils, 78 per cent. Sputum: Negative. Right brachial peripheral neuritis developed on the twenty-fourth day of the patient's illness.

Considerable emphasis has been placed by some observers on the hilar type of atypical pneumonia, certain ones going so far as to imply that all primary atypical pneumonias are primarily hilar in origin. This has not been our experience, though a majority of cases (62 per cent) do show at least partial hilar involvement. In 38 per cent of our series infiltration appeared entirely separate from the hilum during the entire course of the disease.

Atypical examples of the disease are occasionally encountered, which simulate pulmonary tuberculosis, coccidioidomycosis, lobar pneumonia, or other conditions. Isolated patches appearing at the apices resemble the acute exudative type of adult tuberculous infection. During the resolution stage, infiltrations in this region may simulate the proliferative phase of tuberculous involvement. Rapid and complete resolution of the inflammatory process will, of course, readily establish the true diagnosis. In 4 of our sample group of 300 cases infiltrations were so situated and of such character as to require observation over a period of two to three weeks in order to rule out the possibility of tuberculosis. In 2 additional cases, infiltration was of a finely nodular or patchy type, scattered uniformly in both lungs in such a fashion as to require differentiation from miliary tuberculosis, silicosis, or other miliary disease. The clinical course in both these cases, incidentally, was unusually severe and prolonged, but the infiltrations cleared, leaving no trace in the lungs.

Isolated nodular zones of consolidation, especially if small and well circumscribed, may simulate corresponding lesions of coccidioidomycosis but are readily differentiated clinically and by the rapid resolution of the former. The pneumonic type of acute primary coccidioidomycosis, however, may be indistinguishable both clinically and radiographically, except for specific dermatologic and serologic tests in the latter.

Two of our cases presented appearances which, from the films alone, could not be readily differentiated in their initial phases from true lobar pneumonia. In one case uniform consolidation was limited to the right upper lobe; in the other, it occupied the right middle and lower lobes. The clinical and laboratory findings, course, and resolution, however, were so different from those of lobar pneumonia that diagnosis was no problem.

A small percentage of pneumonic consolidations of the primary atypical variety clear uniformly and rapidly in a matter of days, resembling, in this respect, the resolution of lobar pneumonia. But in over two-thirds resolution is a slow, gradual process, requiring a period of two to six weeks. In a typical case, consolidation, which is at first of a confluent, almost homogeneous type, gradually loses its density, becomes mottled, then patchy, finally peribronchial. The peribronchial stage is usually seen beginning about the second week of the disease and lasting until its termination some one to six weeks later. The infiltration at this stage resembles that of the milder cases which, during their entire

course, never progress beyond this point. It is unusual, however, to find a pneumonic infiltration which initially appeared to be of a peribronchial type, progressing to confluent consolidation.

An interesting feature of the disease is its tendency to shift from one lung area to another. It not infrequently happens that as the initial pneumonic infiltration is clearing in one location, an entirely new zone of infiltration will appear in an unrelated lung area, frequently on the opposite side. In some instances, the newly developed consolidation will appear after complete resolution of the initial lesion, as in those patients who are allowed up too soon following the acute stage of the illness. These secondary infiltrations are similar in character and duration to the initial involvement and undergo an independent evolution.

Complications are rare in primary atypical pneumonia. In only 3 of our sample group of 300 did pleural effusion develop, and this in such limited amount as scarcely to fill the costophrenic angle. In 2 cases infiltrations failed to clear completely and after the third month presented an interlacing strand-like appearance characteristic of interstitial fibrosis. The single death in the entire series of 1,200 patients resulted from a secondary ascending myelitis which developed on the eighth day of illness. The appearance of the lung consolidation preceding and accompanying the myelitis was in no way remarkable, and the clinical course and laboratory findings prior to its development were not unusual.

PATHOLOGY

In the few cases of primary atypical pneumonia coming to autopsy, the pathologic findings have been primarily those of an interstitial pneumonia with accompanying destructive or degenerative changes in the alveolar and bronchial epithelium. The interalveolar septa have been described as thickened by hemorrhage and edema, and the interstitial tissues have been crowded with lymphocytic and monocytic cells, while relatively few neutrophils have been present. Adams and Goodpasture found characteristic inclusion bodies in bronchial epithelial cells.

In the single fatal case occurring in our series, destructive and degenerative changes were a prominent feature, interstitial changes were extensive, and neutrophilic leukocytes were numerous. The histopathologic findings were described by the pathologist as follows:

"The lumens of the terminal bronchi are filled by fibrinopurulent exudate, the elements of which are partially degenerated and occasionally diffusely necrotic. Frequently the bronchial epithelium is necrotic. Walls of the bronchi are edematous and infiltrated by neutrophilic leukocytes. Proliferation of their connective-tissue elements is often conspicuous. Vacuolization of the smooth-muscle cells of the bronchi and arteries is common. Some groups of adjacent alveoli contain fairly well preserved fibrinopurulent exudate, and in others this has been replaced by masses of proliferative connective-tissue cells and capillaries. Occasional groups of alveoli have lost identity and are replaced by amorphous eosinophilic material and nuclear debris. The numerically predominant cell of the exudate is the neutrophilic leukocyte, but large mononuclear phagocytic cells are also encountered. The septa in the areas of consolidation are thickened by exudative and proliferative inflammatory changes. Lymphatic channels are rendered conspicuous by networks of fibrin. Gram-Weigert, Giemsa, methylene blue and carbol fuchsin stains do not aid in identification of bacteria. No inclusion bodies are found."

TREATMENT

The treatment of primary atypical pneumonia consists primarily of prolonged bed rest and symptomatic management of cough, headache, sore throat, and other complaints as they arise. Sulfa drugs are not of value and are contraindicated unless secondary bacterial infection is suggested by sputum studies, excessively high white

blood count, or unexpected complications. Convalescent plasma has been used in approximately 75 of the more severe cases at the Santa Ana Army Air Base with some evidence that it is of value early in the course of the disease.

SUMMARY

1. Of a series of approximately 1,500 pneumonia patients admitted to the AAF Regional Station Hospital of the Santa Ana Army Air Base over a period of two years, about 1,200 or 80 per cent have been clinically classified as primary atypical pneumonia.

2. Clinically, one of the most striking features of the disease is the relatively mild symptomatic course as compared with the amount of lung consolidation shown on corresponding chest films. Many ambulatory patients are discovered to have the disease by routine screening films. Prolonged convalescent care is required in many cases because of persistent post-pneumonic asthenia.

3. A normal or depressed white blood count and absence of pathogenic organisms in sputum cultures are among the most significant of laboratory findings.

4. The radiographically demonstrated pulmonary infiltrations fall roughly into two main groups: one, a comparatively mild mediobasal peribronchial type of infiltration; the other, a more or less confluent type of pneumonic consolidation. Unusual types may simulate adult reinfection tuberculosis, miliary tuberculosis, coccidioidomycosis, lobar pneumonia, and other diseases. The majority of pulmonary consolidations are localized to the middle or lower lung fields. They are slow in resolution, usually passing through an intermediate peribronchial stage and occasionally shifting from one lung area to another. There are few complications, and a fatal termination is rare.

5. In the single death in our series, interstitial inflammatory changes in the involved lung tissues were outstanding, and degenerative changes in the bronchial and alveolar walls were a prominent feature.

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The Roentgen Appearance of Lobar and Segmental Collapse of the Lung

III. Collapse of an Entire Lung or the Major Part Thereof

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THE PURPOSE of this paper is to present certain signs which are of value in the recognition of collapse of an entire lung, or the major part thereof. Because of the existing confusion in the use of the terms "collapse" and "atelectasis," we have arbitrarily chosen "collapse" to mean a decrease in size and "atelectasis" to indicate airless alveoli which are smaller than normal. No attempt will be made to discuss the etiology of collapse.

From a total of approximately 85,000 chest examinations conducted at the Massachusetts General Hospital during the past seven years, we reviewed in detail 1,200 in which a diagnosis of tumor, bronchiectasis, foreign body, or tuberculosis was made. After discarding the cases in which the roentgenograms were inadequate (films in two projections, the postero-anterior and lateral, being considered the minimal requirement for determining the size of a lobe or its segments), approximately 600 remained in which at least one lobe was less than two-thirds of its normal size. Only collapse produced by intrinsic disease of the lung was included; collapse attributable to extrinsic factors, as pneumothorax, pleural fluid, or a pleural tumor, was excluded.

Analysis of this group of 600 cases revealed that collapse was limited to a single lobe, or segment, in 71 per cent, that it involved two or more lobes in 18 per cent, and was massive in 11 per cent. Collapse of the left lung was more frequently observed than collapse of the right lung. The various lobes were involved as follows: left lower lobe, 42 per cent; right lower lobe, 26 per cent; right middle lobe, 26 per cent; left upper lobe, 8 per cent; right upper lobe, 8 per cent. The percentage of cases with extensive collapse would have been greater had all the cases in which massive collapse followed operative procedures been included. In many of these patients, however, examination was limited to a single portable roentgenogram, which was insufficient to warrant their inclusion in this study. Since our present interest is to describe as accurately as possible the findings in collapse of an entire lung, or the greater portion of a lung, a group of 30 cases in which the requisite number of roentgenograms were available was selected as a basis for our conclusions. Detailed description of collapse of the various lobes will be presented in subsequent papers.

Collapse of an entire lung, whether it be acute or chronic, usually shows the characteristic roentgenologic signs by which collapse has long been recognized (1*b*, 2, 3, 4): an abnormal shadow of increased density, elevation of the diaphragm, displacement or shift of the mediastinum, and narrowing of the rib spaces.

In acute collapse of the lung, the shadow of increased density is as a rule homogeneous, indicating complete atelectasis, although certain segments of some lobes may not be atelectatic. The structure of the involved lung, including the hilar shadow and septa, is obscured. The side of the chest which contains the collapsed lung is more radiopaque than the opposite side, due to increase of soft-tissue density per unit volume without air, whereas the density of the uninvolved side is diminished as a result of compensatory emphysema. The shadow of increased density, representing collapse of the greater portion of a lung, may at first glance be confused with

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Fig. 1 (portable roentgenogram). Acute collapse of the right lung four days following subtotal gastrectomy. The shadow of increased density appears to involve the greater portion of the right lung. The heart and mediastinum are displaced to the right. The rib spaces are questionably narrowed. The position of the diaphragm is not definite. A roentgenogram taken five days later showed the lung considerably re-expanded.

pneumonia or pleural effusion. Pleural effusion, however, is a space-consuming lesion which displaces the lung, the mediastinal contents, and the diaphragm, producing a shadow which is often larger than the area usually allocated to the lung; while pneumonia may produce a homogeneous shadow of increased density but little or no change in the size of the lung.

The mediastinum is displaced toward the collapsed lung and shows, during fluoroscopy, a definite inspiratory shift to the side of the lesion. The amount and type of displacement of the mediastinal contents are essentially the same regardless of which side of the chest is involved. The adjacent border of the heart is obscured by the shadow of density, and fluoroscopically the pulsations in this area are usually invisible. If the diaphragm is visible, it is seen to be elevated and ordinarily shows some limitation of motion during fluoroscopy. Since in most cases its upper surface is obscured by the shadow of increased density, determination of its position will depend on demonstration of its lower surface, particularly on the left side. This can be done easily when the diaphragm is outlined by underlying gas in either the stomach or colon. If this is not the case, demonstration of the fundus of the stomach with barium will usually show the position of the diaphragm. The right side is much more difficult to localize accurately, but if there is no reason to assume abnormality in the size of the liver, a suggestion of the position of the diaphragm can be gained by locating the inferior margin of that organ. The rib spaces as a rule appear to be narrowed on the side of the chest involved.

If it is borne in mind that the last three signs of collapse are all the result of a *decrease in size* of the involved lung, collapse of a lung is less likely to be confused with pneumonia, pleural effusion, or other disease process.

In chronic collapse of the lung, the shadow of increased density could not, in some instances, be differentiated from that seen in acute collapse, whereas in others it became so small that it was difficult to recognize. The collapsed lung lies posteriorly and medially; on the left side, it is often partially obscured by the heart or other mediastinal contents, while on the right, it blends with the shadow of the diaphragm, liver, and mediastinum. The blending of the shadow of increased density with the adjacent margin of the heart makes it impossible to determine the exact size of either the heart or of the shadow of density. The mediastinum is displaced toward the side of the lesion, though fluoroscopically the mediastinal shift is usually less apparent than in acute collapse. The heart moves toward the side of the lesion and posteriorly. The uninvolved, emphysematous lung tends to herniate through the mediastinum. In our experience, this herniation has been confined to the anterior mediastinum (1*a*).

Recognition of pulmonary herniation is largely dependent upon the lateral roentgenogram, which demonstrates an increase in the distance between the sternum and

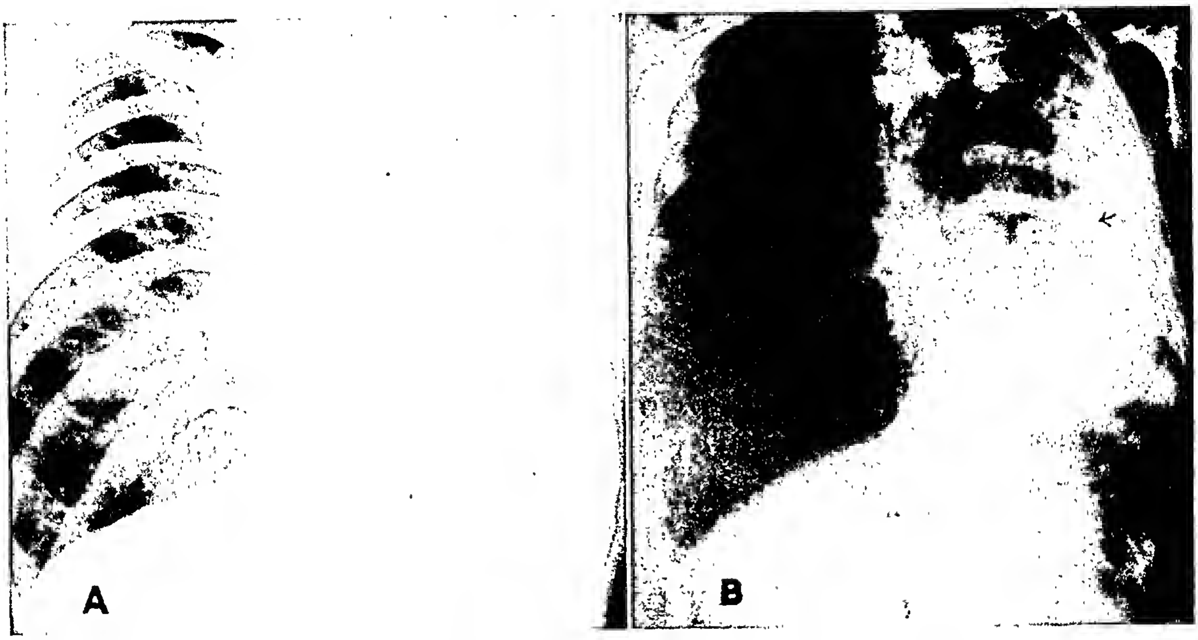

Fig. 2. Chronic collapse of the left lung due to bronchiectasis. A. Hazy density obscures the entire left lung field, and some mediastinal displacement is apparent. B. Grid film demonstrates the displacement of the trachea and mediastinum. The edge of the herniated lung is clearly seen (arrows). The bronchiectatic cavities within the left lung are visible. The approximate position of the left diaphragm is determined by the position of the gas-filled colon. See also Figure 2C.

the anterior border of the heart and the ascending aorta. In the anteroposterior Bucky and postero-anterior grid films it is usually possible to determine the margin of the herniated portion of the lung. If the hernia is small, the margin may be just beyond the mid-line, while a large hernia may extend to the lateral chest wall. The size of the hernia depends on the amount and the duration of the collapse. In some cases, it may be of such degree that the herniated, uninvolved lung may almost completely aerate the opposite chest.

The presence of a hernia is frequently not apparent until one observes the distribution of the vascular shadows. Close examination of these will reveal that there are altogether too few shadows within the herniated portion of the lung as compared with normal lung. In extreme cases of herniation, the apparent aeration by the emphysematous lung tends to create the impression that the collapsed lung is fairly well aerated. Herniation of the right lung in collapse of the left has been more frequent than the reverse. Likewise, herniations to the left side have been considerably larger than those to the right.

Fig. 2C. Lateral view of case shown above, showing large space occupied by the mediastinal hernia between the sternum anteriorly and collapsed lung and heart posteriorly. Total pneumonectomy performed.

In this study, a sizable hernia has been frequently observed in chronic collapse but has not been seen in acute collapse.

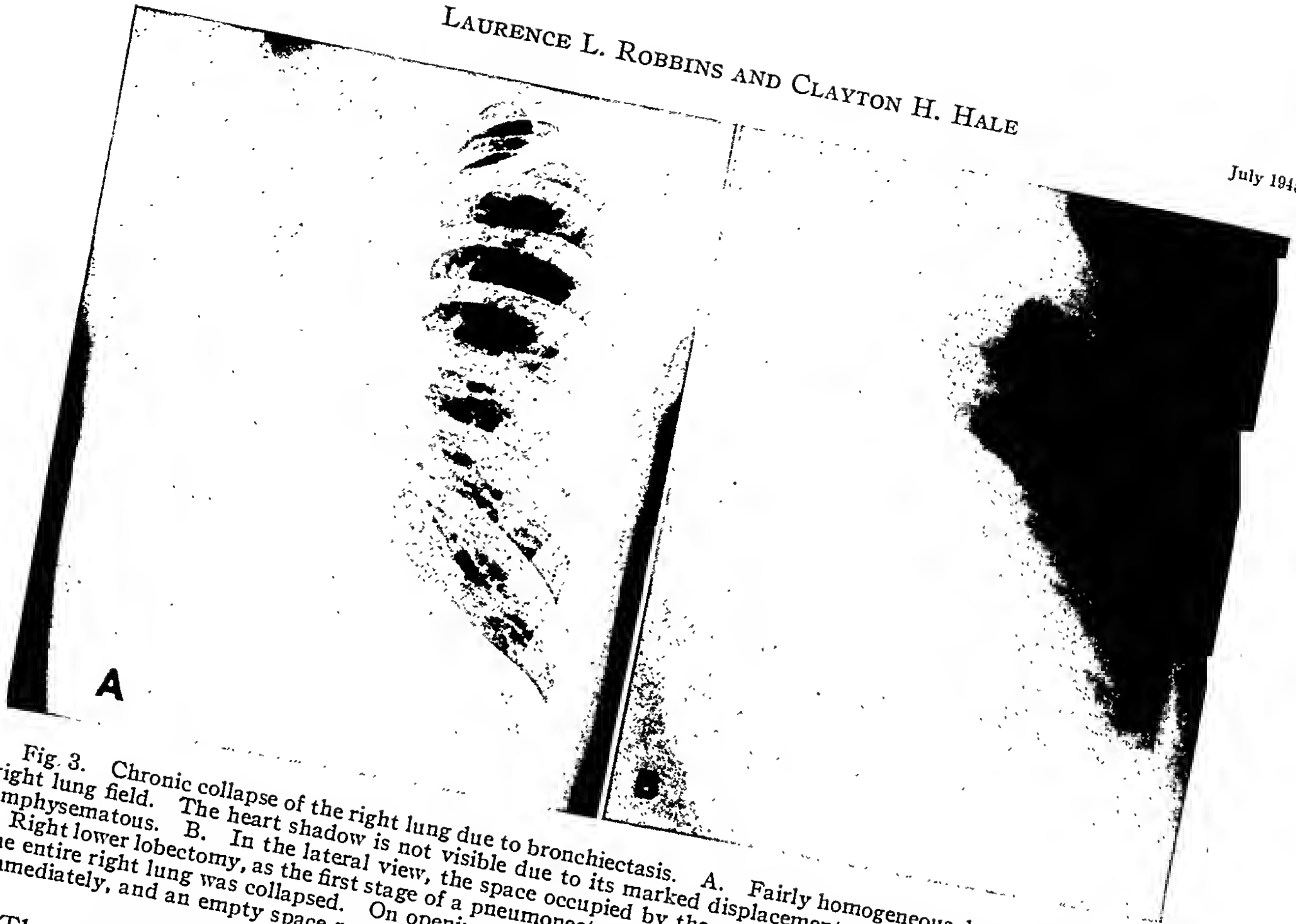

Fig. 3. Chronic collapse of the right lung due to bronchiectasis. A. Fairly homogeneous density obscures the right lung field. The heart shadow is not visible due to its marked displacement to the right. The left lung is emphysematous. B. In the lateral view, the space occupied by the mediastinal hernia is clearly visible. Right lower lobectomy, as the first stage of a pneumonectomy, was performed. At operation, it was found that the entire right lung was collapsed. On opening the right pleural cavity, the heart shifted to its normal position immediately, and an empty space remained where it had previously been located.

The changes in the diaphragm are usually less marked in chronic than in acute collapse, because the herniated lung from the opposite side is of sufficient size to compensate partially for decrease in size of the involved lung. This factor also limits somewhat any apparent narrowing of the rib spaces. In many instances there is associated scoliosis of the dorsal spine with the convexity away from the side of the collapse. In the absence of scoliosis, or unless the onset of collapse occurred in childhood, it is doubtful if the narrowing of rib spaces is more than one would expect to find during full expiration.

The tendency of the involved side of the chest to be smaller than normal holds true for chronic as well as for acute collapse, though, because of the herniated lung, the decrease in size is generally not so great in chronic collapse. In contrast, however, the shadow of increased density is usually smaller in chronic than in acute collapse.

CONCLUSIONS

Careful study of the roentgenograms of patients suffering from collapse of an entire lung has shown two striking differences between acute and chronic collapse:

1. In acute collapse the shadow of the collapsed lung is readily seen; in chronic collapse it may be difficult to identify.

2. Herniation of the uninvolved lung through the mediastinum was a frequent finding in chronic collapse but it was not seen in acute collapse.

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Atrophy of Terminal Phalanges in Clubbing and Hypertrophic Osteoarthropathy[1]

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THE PATHOGENESIS of clubbing of the fingers and toes has remained obscure in spite of numerous investigations. Since Hippocrates' original description of this phenomenon in a patient with empyema it has been found associated with various conditions such as cardiac, pulmonary, and gastro-intestinal disease. Clubbing has been recognized as both acquired and hereditary in type and has been classified as idiopathic in cases in which an etiologic factor has not been established. Hypertrophic osteoarthropathy is now generally believed to be a more pronounced and advanced stage of the same process (1).

The bone changes occurring in hypertrophic osteoarthropathy have attracted considerable attention since the original investigations of Bamberger (2) and Pierre Marie (3). The condition is characterized by an irregular periosteal thickening of the shafts of the involved bones. In advanced stages subperiosteal new bone formation may be so pronounced as to result in marked thickening of the bone shafts and in conspicuous swelling of the involved parts. The bones most frequently affected are the long bones of the extremities, the metacarpal and the metatarsal bones, the proximal phalanges, and clavicles. The vertebrae and ribs are rarely involved.

The bone changes taking place in the terminal phalanges in simple clubbing and hypertrophic osteoarthropathy deserve special consideration. Earlier observers believed the enlargement of the distal portions of the fingers and toes to be the result of bony overgrowth (2). This conception was revised after roentgenologic studies showed the clubbing to be attributable chiefly to enlargement of the soft tissues. In most instances no changes whatsoever were observed in the terminal phalanges. Thus, Hodges, Phemister, and Brunschwig (4) claim that "almost invariably there are no bone changes of the terminal phalanges at the site of clubbing." In some cases, however, a characteristic burr-like overgrowth of the unguinal process of the phalanx was observed. Locke (1), who examined a large series of patients, noted hypertrophic changes of the terminal phalanges in 28 per cent of those with simple clubbing. Of 5 patients with advanced hypertrophic osteoarthropathy observed by this investigator, all showed hypertrophic changes of the terminal phalanges.

Mendlowitz (5), in his review of clubbing and hypertrophic osteoarthropathy, refers to a small number of cases which showed characteristic atrophic changes of the terminal phalanges. These cases are reported in the foreign literature. To our knowledge, no similar reports have appeared in the American and English literature.[2]

The recognition of these atrophic changes in clubbing and hypertrophic osteoarthropathy would seem to be of importance to the roentgenologist, in the differential diagnosis of conditions characterized by destructive changes in the terminal phalanges.

On account of the rarity of such observations, the two cases which follow were thought to merit brief description.

CASE I: E. S., a colored laundress, age 59, was seen at Grady Hospital with great enlargement of the distal portions of the ulnae, radii, tibiae, and fibulae, as well as broad clubbing of the soft tissues

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[1] From the Departments of Roentgenology and Medicine, Grady Hospital and Emory University School of Medicine. Accepted for publication in October 1944.

[2] Since preparation of this paper we note that a case similar to our Case II has been described in the recently published handbook, *The Arthropathies*, by A. A. de Lorimier, Year Book Publishers, Inc., Chicago.

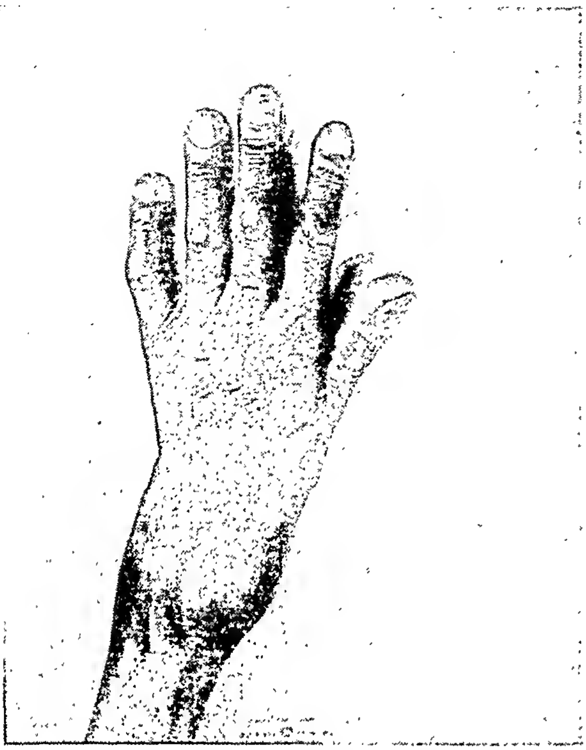

Fig. 1. Case I: Left hand, showing clubbing of fingers and swelling of distal forearm.

of the distal segments of all digits (Fig. 1). She showed flexion deformity of the hands due to limitation of extension at the enlarged proximal interphalangeal articulations. These enlargements were virtually free from pain, although there was arthralgia in some other joints.

The patient stated that these enlargements had been present all her life, and had been a source of childhood nicknames, but she believed there had been progression of enlargement in the past twelve years.

She showed no cyanosis, had normal peripheral pulses, and presented no sign or history of cardiorespiratory or other chronic disease. None of her seven siblings had similar osteoarthropathy.

Laboratory studies recently showed insignificantly mild normochromic anemia, normal urine, and a normal serum calcium level.

Roentgen Examination: The distal portions of radius, ulna, tibia, and fibula on both sides showed marked widening of the shafts (Figs. 2 and 3). There was extensive formation of subperiosteal cancellous bone with apparent absorption of the original cortex. Small irregular spurs protruded from the surface of the involved bones into the soft tissues. These changes were also observed in the fifth metatarsal bones. The remaining metatarsal bones, the metacarpal bones, and the proximal phalanges had

Figs. 2 and 3. Case I: Subperiosteal bone formation in left forearm; widening of shafts of tibia and fibula, with thick layers of subperiosteal bone.

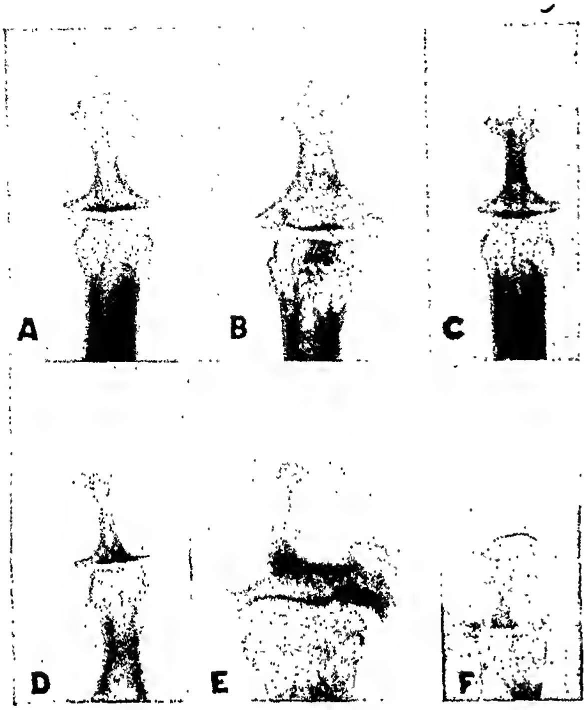

Fig. 4. Case I: A. Right 3d finger. B. Right 1st finger. C. Right 4th finger. D. Left 5th finger. E. Right 1st toe. F. Left 5th toe. Hypertrophic changes are shown in A, while various stages of atrophy are seen in B to F.

the usual appearance. The middle phalanges of the toes showed a thinning of the shafts. Characteristic atrophic changes of varying degree were observed in the terminal phalanges of the fingers and toes (Fig. 4, B–F).

CASE II: C. M., a colored male, was said to have been a "blue baby" at birth. He was always easily fatigued, and when he was seen at the age of 14 years at Grady Hospital for syncopal attacks and dyspnea, a diagnosis of "congenital heart disease with cyanosis" was made. On the basis of physical examination, blood chemical studies, and roentgen examination, the accepted clinical diagnosis was "tetralogy of Fallot."

In his terminal illness, at the age of 30 years, when he presented the clinical picture of recurrent cerebral embolism, he was cyanosed, aphasic, and decompensated, with typical soft-tissue clubbing of the distal digital segments without evidence of osteoarthropathy. Autopsy was not permitted.

Roentgen Examination: The unguinal processes of the terminal phalanges of the toes showed evidence of atrophy (Fig. 5). No bone changes were observed throughout the terminal phalanges of the fingers. The long bones revealed no hypertrophic changes.

DISCUSSION

From the bone changes observed in these two cases, it can be assumed that the absorption of the terminal phalanges is preceded by hypertrophic changes. These hypertrophic changes are still well shown in the terminal phalanx of the right middle finger in Case I, the unguinal process of which shows a burr-like overgrowth (Fig. 4, A). The shaft of this phalanx appears increased in width, and there is some widening of the base. Figure 4, B to F, shows, also, various stages of atrophic change in the terminal phalanges in Case I, and in Figure 5, A to C, a similar process in Case II is illustrated. It is believed that the structural changes have taken place in the following sequence. First, a gradual splitting and notching of the unguinal process occurs, with the distal convex margin of the terminal phalanx becoming flattened and concave (Fig. 4, B and C; Fig. 5, A and B). At the same time a concentric atrophy of the shaft may be initiated so that the terminal phalanx assumes a collar-button-like appearance (Fig. 4, D and E). Finally, complete absorption of the unguinal process may give the terminal phalanx the appearance of a thumb tack (Fig. 5, C). In some instances the absorption progresses to complete atrophy of the shaft and unguinal process, so that only the base of the terminal phalanx is seen as a disk-like remnant (Fig. 4, F).

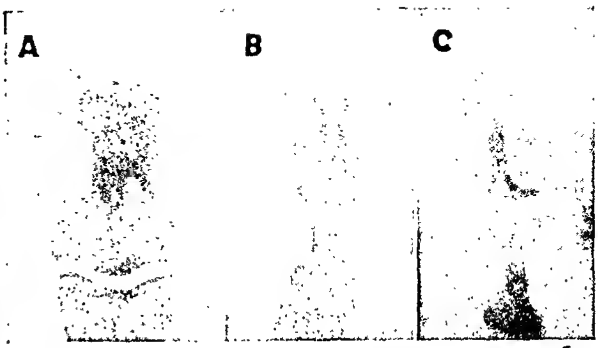

Fig. 5. Case II: A. Left 1st toe. B. Left 2d toe. C. Left 4th toe. All three roentgenograms show various stages of atrophy.

Various explanations have been offered as to the development of the atrophic changes. Lippmann (6), who observed this process in an eighteen-year-old patient with congenital pulmonic stenosis, believed that the swelling of the soft tissues, by exerting a constant pressure on the

terminal phalanges, resulted in atrophy. He arrived at this conclusion because the atrophic changes were most pronounced in those fingers and toes which showed maximum clubbing. Singer (7), who recorded a similar process in a patient with congenital heart disease, suggested local circulatory disturbance as the cause of the changes in the terminal phalanges. He noted, on capillaroscopic examination, elongation and dilatation of the small blood vessels of the fingers and toes and advanced the theory that the dilated vessels could produce erosion of the surface of the adjacent bone. The pathologic anatomic studies of Crump (8) did not confirm this conception.

Histologic and radiologic observations have demonstrated that the osseous changes of hypertrophic osteoarthropathy are not merely the result of apposition of periosteal bone. In advanced cases lacunar absorption and osteoporosis of the newly formed subperiosteal bone and underlying original bone may attain significance (9). The absorptive changes demonstrated on pathologic examination were usually studied in the long bones of the extremities. It seems conceivable that in the terminal phalanges hypertrophic changes may be followed by the same absorptive process, resulting in atrophy.

In differential diagnosis of the atrophic changes of the terminal phalanges which are described above, all conditions which are associated with destructive changes of the fingers and toes should be considered. In Raynaud's disease, scleroderma, and psoriasis, bone atrophy is usually not observed unless atrophic changes of the soft tissues have taken place. In the neurotrophic disorders, such as syringomyelia and tabes dorsalis, the tips of the fingers and toes may assume a club-shaped appearance due to inflammatory soft-tissue swelling. The destructive changes of the phalanges in leprosy are in most instances caused by a neurotrophic disturbance and resemble syringomyelia to a certain extent (10). Characteristically, the bone changes in these neurotrophic disorders are most prominent where fingers and toes are exposed to a maximum of trauma. Thus the heads of the metatarsal bones as the points of weight-bearing show most of the involvement in the form of concentric atrophy. Contrary to this finding, the atrophic changes in clubbing and hypertrophic osteoarthropathy are predominant in the terminal phalanges. It will be noted that the fingers in neurotrophic disturbances may be shortened, assuming a stubby appearance. Shortening of fingers and toes should, however, not be expected in patients with clubbing and hypertrophic osteoarthropathy.

SUMMARY

Two cases of clubbing of the fingers and toes are presented, in which the terminal phalanges show various stages of atrophy. One of these cases revealed advanced hypertrophic osteoarthropathy. The atrophic changes in the terminal phalanges are thought to have been preceded by hypertrophy, which is the bone change frequently described in this condition. The differential diagnosis of atrophy of the terminal phalanges is discussed.

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Treatment of Carcinoma of Prostate by Irradiation[1]

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PROSTATIC CANCER is recognized as one of the most frequent types of malignant growth in man. Wolff, in a review of medical literature in 1899, found only 83 recorded cases of carcinoma of the prostate. Today the literature abounds with reports of this disease and the incidence is placed at 14 to 20 per cent of all prostate tumors.

The prognosis for cure in carcinoma of the prostate is bad for two reasons: (*a*) in the early stages the disease is without symptoms; (*b*) early metastatic invasion, by perineural routes, of the pelvis, sacrum, vertebrae, and femur occurs. Hence, the curative value of early radical surgery is limited to a very small percentage of cases—according to Lowsley (1), less than 5 per cent. Formerly, the prognosis for alleviation of symptoms and any appreciable extension of life was also bad. Today it is much better. That this improvement is due to a more alert understanding of the influence of certain male hormonal substances on the cellular structure of prostatic tissue cannot be denied. Since 1934, when the theorem of the probable relationship between testicular hormones and carcinoma of the prostate was discussed by this essayist before the Southwestern Branch of the American Urological Association, in St. Louis, extensive correlative clinical, pathological, and biochemical studies have led to the evolution of a specific, though limited, therapeutic technic.

The investigative work of Kutscher and Wolbergs (2) established that the normal prostate tissue is extremely rich in the enzyme, "acid" phosphatase. The Gutmans (3) found acid phosphatase in primary tumors of the prostate and also in metastases at various sites. Determination of the serum acid phosphatase level, then, is a valuable aid in the diagnosis of bone lesions secondary to carcinoma of the prostate. Whenever the acid phosphatase level has been found to be appreciably increased, metastases have invariably been present. They may, however, occur without a rise in the acid phosphatase level. Thus there are false negative but no false positive reactions.

A high serum "alkaline" phosphatase level is of value in differentiating Paget's disease of the bone from bone metastases arising from carcinoma of the prostate. The alkaline phosphatase level is high, also, in biliary obstruction, generalized osteoporosis, hyperthyroidism, and active rickets.

The activity of the male hormone influences the growth of adult prostatic epithelial cells which characterizes prostatic carcinoma. This activity may be measured by the serum acid phosphatase determination.

Most malignant prostate tumors are adenocarcinomas and consequently relatively radioresistant. It is noteworthy, nevertheless, that they are decidedly more radiosensitive than the same type of tumor in the digestive tract. A comparative histologic study of tumor tissue in several instances, before and after high-voltage irradiation, shows a varying degree of cellular damage. Not infrequently one observes complete destruction of the nucleus, with only the cell walls remaining visible. A varying degree of pyknosis, with a clear pale-staining substance distending the cytoplasm, is seen in certain instances, while again the cytoplasm is granular, with marked karyokinesis. In no instance is there such extensive cellular damage that one cannot find scattered cells retaining their viable staining characteristics.

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[1] Presented at the Joint Meeting of the American Roentgen Ray Society and the Radiological Society of North America, Chicago, Ill., Sept. 24–29, 1944.

It is quite the universal concept to limit the origin of carcinoma to the posterior lobe. This idea should be dissipated; cancer may, and does, originate in any portion of the prostate or its lobules. This fact is most important in judging the clinical index for therapeutic purposes. The fixed indurated nodule palpated in the posterior lobe in a patient under sixty years of age is more actively malignant than the large nodular tumor palpable rectally in a patient past sixty years.

In 1932, a study correlating the pathological data and clinical observations in 501 cases established a satisfactory clinical index for therapeutic purposes. *Group A*, or the least malignant group, comprising 62 per cent of the cases, is characterized by an age factor of 65 or over, with 200 c.c. or more of urine, the tumor developing in an already established benign hypertrophy and presenting the histologic characteristics of adenocarcinoma with mature cells and definite alveolar structure. *Group B*, intermediate in malignancy, accounts for 26 per cent of the cases; the patients are between 55 and 65 years of age, with symptoms of ten to twenty months' duration. They frequently complain of pain but give no evidence of metastasis. Examination reveals a small, firm, irregular tumor. Histologic study shows anaplasia, with rapid disappearance of the adenomatous characteristics. *Group C*, the most malignant group, comprises the remaining 12 per cent of cases. The patients are under 55 years of age, with little or no residual urine, with pain and demonstrable metastases, and with symptoms usually of less than a year's duration. Rectal examination reveals a rather small, diffusely indurated prostate, not characteristically diagnostic, with a histologic picture of small round cells and anaplasia. While this classification cannot always be arbitrarily applied, it helps greatly, nevertheless, in the selection of therapy and establishing prognosis.

In a report (4) before the American Urological Association in 1941, dissipation of the androgenic hormone by direct testicular irradiation in addition to regional irradiation was advocated in the treatment of carcinoma of the prostate. A study of 11 cases was presented, all of which had been treated by prostatic resection and regional irradiation, with adjunct irradiation directly to the testicles. When the report was rendered, 8 of the 11 patients were alive, the longest survival being seven and the shortest three years. Five of the surviving patients had been examined during the year of the report. Rectal examination in almost every instance presented minimal findings which would lead the examiner to conjecture a diagnosis of carcinoma of the prostate. The prostatic bed was usually smooth, resilient, and free of nodules. From the comparative study made in that report, it was concluded that the addition of planned testicular irradiation definitely enhanced the survival chances of the patient. It is known that at least 3 patients from the series reported in 1941 are still living.

This presentation is concerned with further clinical experiences as the result of therapeutic application of x-rays. Huggins (5), in a discussion of the effect of irradiation of the testes in advanced prostatic cancer, presents the clinical course in two cases in which the testicles were not subjected to direct planned irradiation but were dependent upon "back-scatter" from regional irradiation. Indeed, in one case the testes were protected in the usual way with lead rubber but undoubtedly received back-scattering of radiation. Six months later this patient was given regional irradiation without protection of the testes. Huggins says: "The testes in each case presented similar cytologic characteristics, namely, profound atrophy of the germinal epithelium with preservation of Sertoli cells and apparent or real hyperplasia of the Leydig cells." He concludes: "It is thus apparent that roentgen ray irradiation, in the amounts stated, is ineffective in destroying the secretory function of the testes and is inadequate as a therapeutic agent in prostatic cancer in man."

It is unfortunate that so good a research worker as Huggins should publish such an

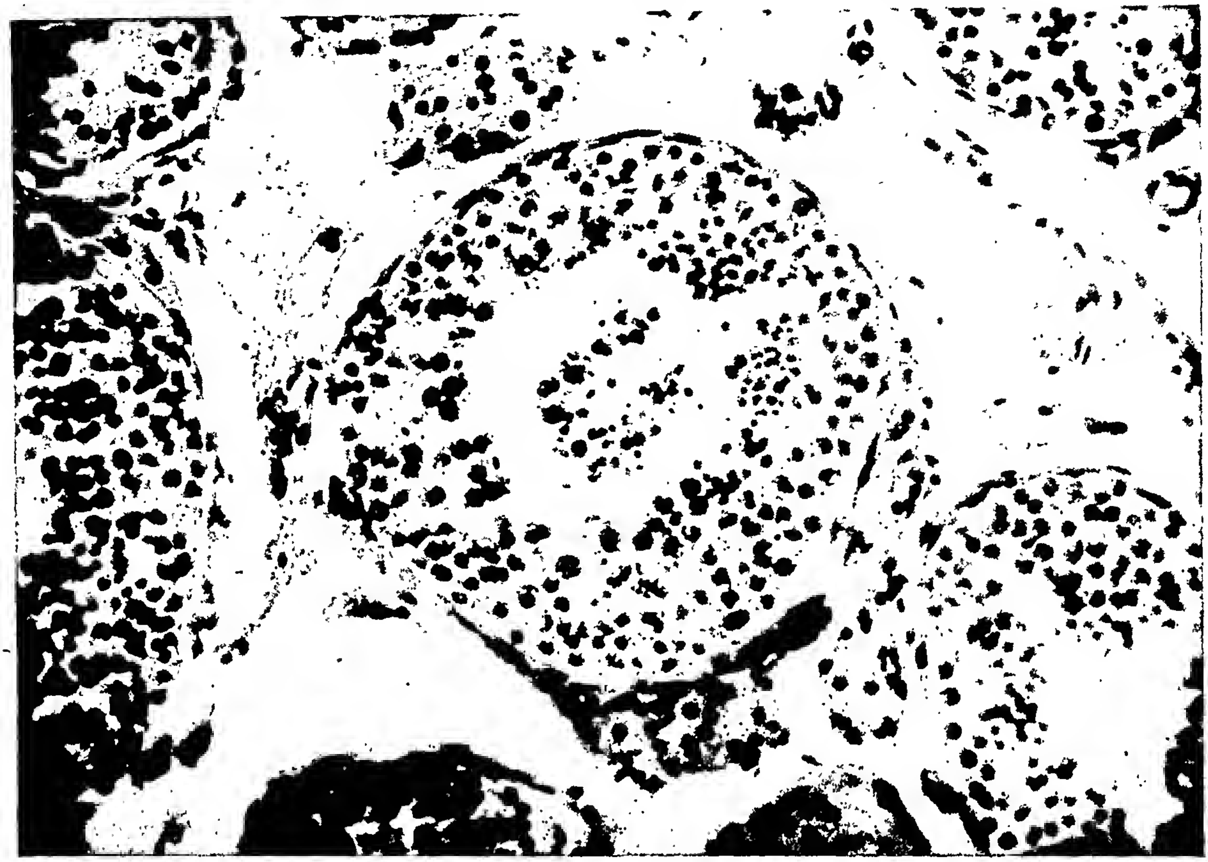

Fig. 1. Histology of the normal testicle showing seminiferous tubules with spermatogenic cellular elements, the loose interstitial meshwork of fibrous reticulum representing the so-called interstitial or Leydig cells.

inaccurate and inadequate report. Without a parallel series of roentgen and surgical castration cases, he is not in a position to pronounce a negative dictum relative to the effects of planned testicular irradiation. That the effect on the testicular elements, in the dosage used, is profound is testified to by the accompanying illustrations. It is not within my province, as a urologist, to discuss before a meeting of roentgenologists the technical factors involved in testicular irradiation. A sample report reads as follows: "In way of summary, this patient began his irradiation therapy May 22, 1942, at which time he was given 1,800 r direct irradiation to the testicles, divided into daily doses of 300 r. The quality of beam used in this therapy is 200 kv.p., 1.5 mm. copper + 1 mm. aluminum, half-value layer 0.9 mm. copper. Beginning May 29, 1942, this patient received fractionated irradiation about the pelvis using a beam with half-value layer of 3.5 mm. copper, kv.p. 400. He received a total of 2,000 r (in air) to each of four pelvic ports, which gives a depth dose, of about 5,500 tissue roentgens to the mid pelvis."

It is, however, incumbent that the clinical picture be discussed. As a prelude to any treatment, a biopsy study is mandatory to determine the type and grade of the tumor, and a roentgenologic and phosphatase-level survey is made for metastases. An attempt is made to classify the case in accordance with the clinico-pathological criteria aforementioned for determining upon intensity of treatment and for purposes of prognosis. As a rule, I find that the case dovetails into this classification quite well.

During the two-year period ending in May 1943, 27 cases of carcinoma of the prostate were seen, 12 of which were treated by resection with regional and testicular irradiation, 8 by resection, irradia-

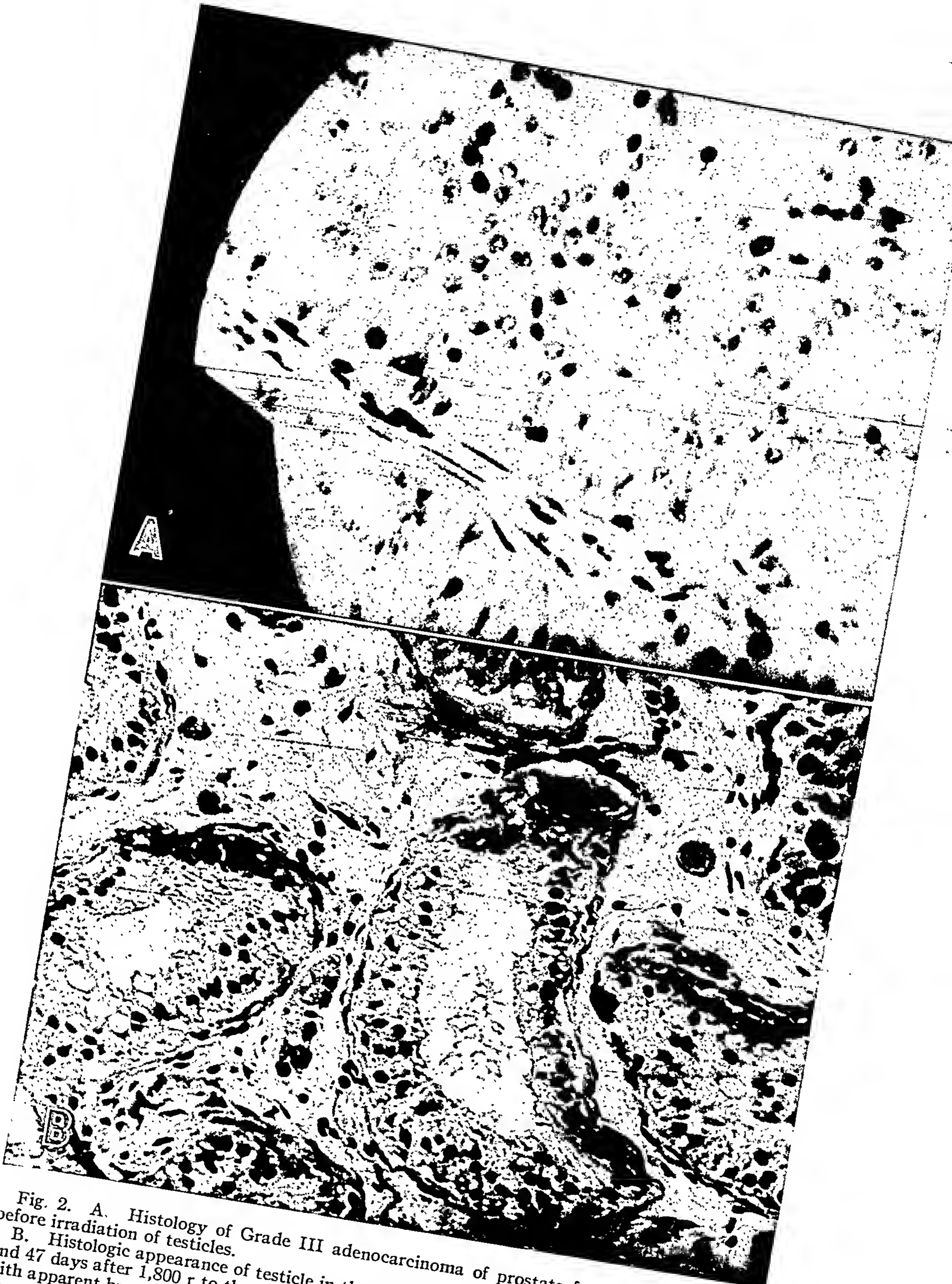

Fig. 2. A. Histology of Grade III adenocarcinoma of prostate following resection and before irradiation of testicles.

B. Histologic appearance of testicle in the same case immediately after 1,200 r to testicles and 47 days after 1,800 r to the pelvic region. Note swelling of interstitial fibrous reticulum with apparent hypertrophy of Leydig cells and marked degeneration of spermatogenic cellular structures. See also Fig. 2, C and D.

Fig. 2. C. Section of testicle (from case shown in Fig. 2, A and B) one year after irradiation, showing marked degenerative change in spermatogenic cellular elements with complete destruction and dissipation of Leydig cells. (Biopsy taken by courtesy of Dr. Roger Barnes and section made by pathologist in White Memorial Hospital, Los Angeles.)

D. Section of prostate (from same case) taken one year after original biopsy showing carcinoma and one year after 1,500 r testicular and 1,800 r regional irradiation. This study reveals no histologic evidence of carcinoma of the prostate. (Biopsy taken and study made in White Memorial Hospital, Los Angeles.)

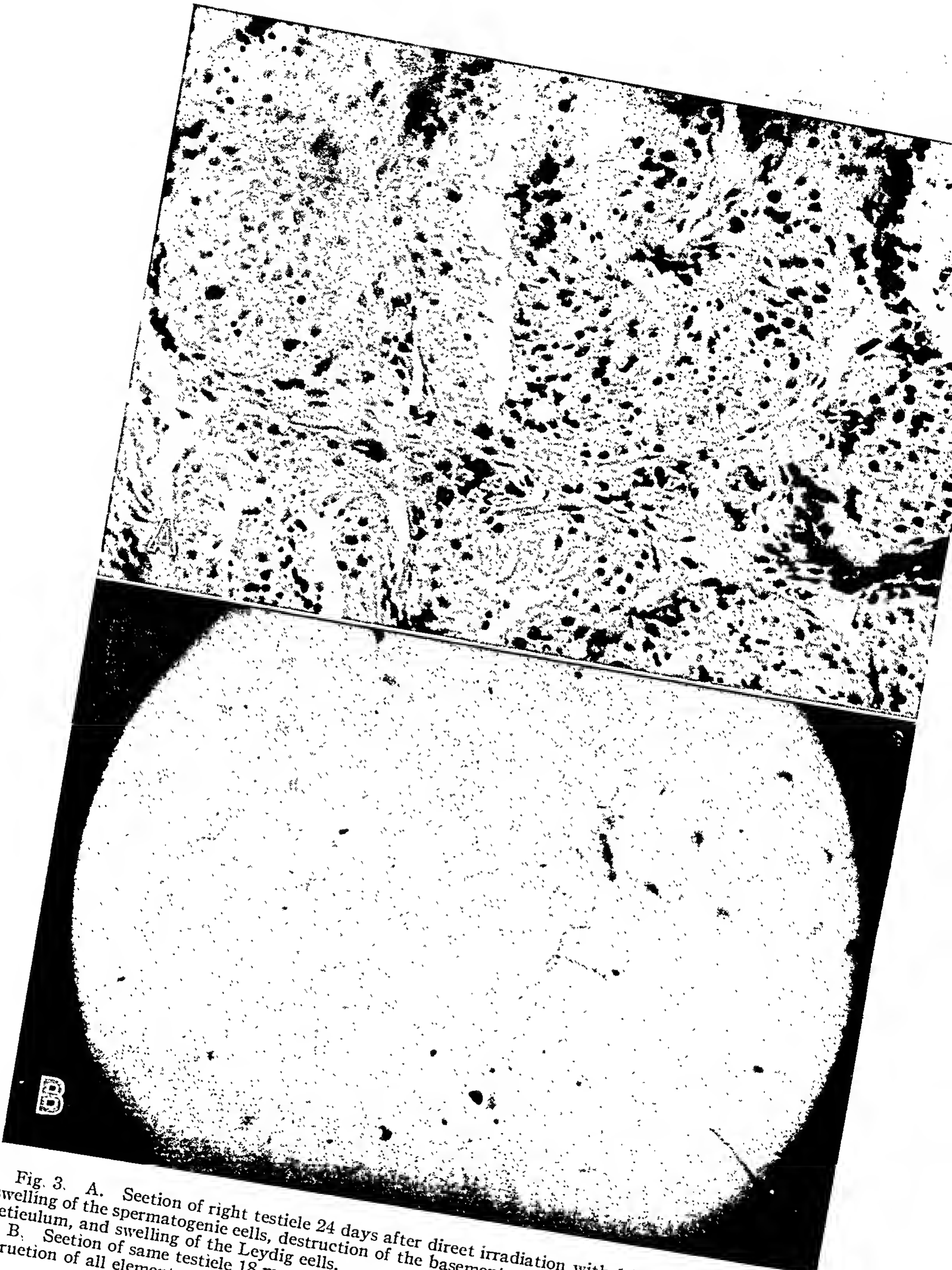

Fig. 3. A. Section of right testicle 24 days after direct irradiation with 1,500 r, showing marked swelling of the spermatogenic cells, destruction of the basement membrane, increase in the interstitial reticulum, and swelling of the Leydig cells.
B. Section of same testicle 18 months after direct irradiation with 1,500 r, showing complete destruction of all elements, especially interstitial. See also Fig. 3, C.

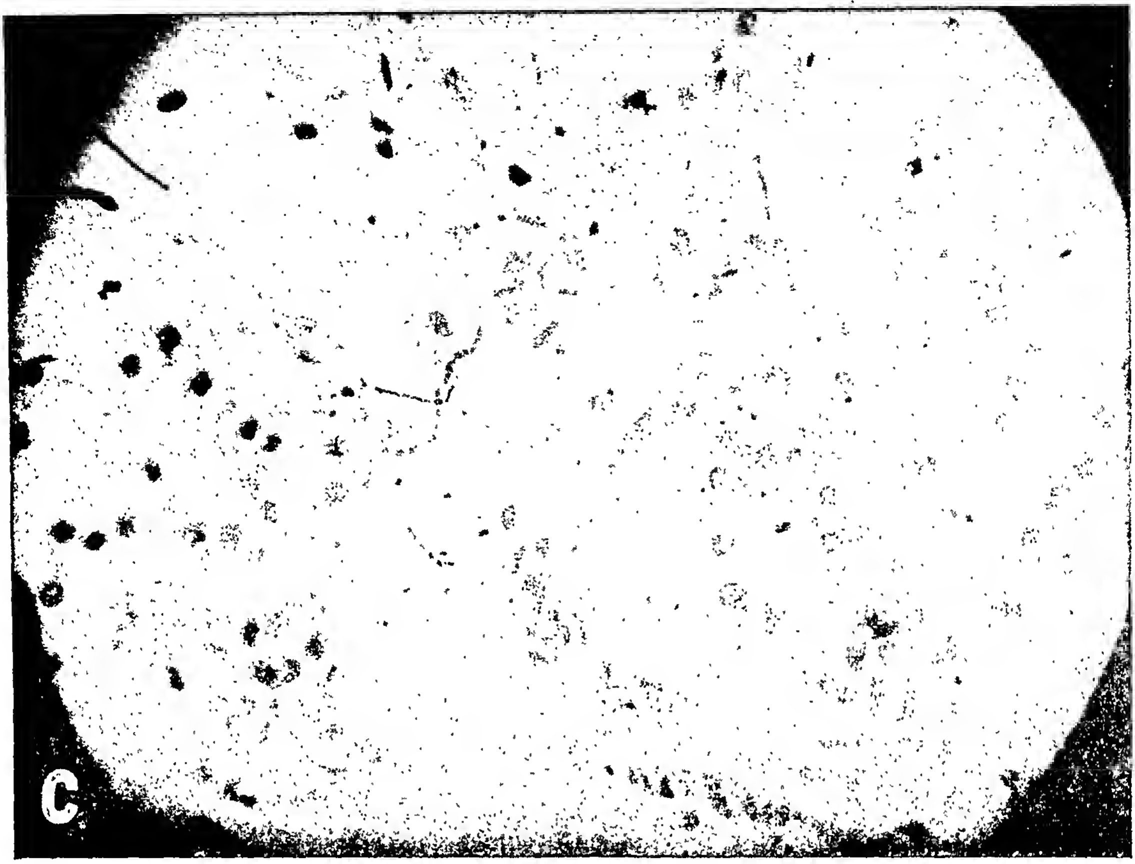

Fig. 3. C. Section of left testicle (same case as Fig. 3, A and B) 18 months after irradiation of the pelvic region, the testicle receiving back-scatter only. The destruction is not nearly so evident as in the right testicle, which received direct irradiation. This left testicle was "leaded off" when direct irradiation was given to the right testicle.

tion, and estrogen therapy, and 7 by orchiectomy.

Of the 27 patients, 5 are dead at the date of this report. Two of these were subjected to primary surgical castration, one on my service and one elsewhere. Both manifested primary improvement in their osseous and remote metastases, with secondary reactivation. All forms of treatment were without avail, and the patients died at nine and thirteen months, respectively. One patient was admitted with a large, soft rectal and intravesical intrusion. The diagnosis was hypertrophied prostate, and a prostatectomy was performed. The pathologist reported most of the tissue to be benign adenoma but with several sections showing Grade IV adenocarcinoma. Regional and testicular irradiation was promptly instituted but rapid osseous and pulmonary metastases ensued. The phosphatase level in this case was 2.8 units (K.A.) when taken promptly upon report of carcinoma by the pathologist. Nevertheless, it is felt that metastases were well advanced on admission. The phosphatase level rose progressively to 14.2 units (K.A.) in keeping with the spreading metastases. Two months after irradiation, an orchiectomy was done but did not change the course of events. The patient died eleven months following prostatectomy, of generalized metastases. The fourth death occurred seventeen months after resection followed by partial regional irradiation only. Because of a severe systemic reaction the patient, a diabetic, refused further treatment. Over the several months following resection, the phosphatase level ascended to 8.8 units, with metastases and pathological fracture of the right femur. Death was apparently due to carcinoma.

Roentgen Study of the Ankle in Severe Sprains and Dislocations[1]

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Philadelphia, Penna.

THERE HAS MORE recently been an increasing tendency toward the use of the x-rays in clinical medicine to demonstrate not only the anatomical structure and pathological lesions of a part but also its physiology and any disturbances thereof. This is well illustrated in roentgen studies of the urinary and digestive tracts. The study of the skeletal system has not kept pace with that of other systems in this respect and, even today, is for the most part on a purely anatomical basis.

In examination of the ankle, roentgenograms are obtained, as a rule, in the anteroposterior and lateral positions. If no bony injury or abnormality is demonstrable, the report usually reads: "Nothing abnormal is seen, but this examination does not exclude injury to the soft parts." In other words, our examination fails to record the presence of a soft-tissue injury. This was brought forcibly to our attention by the following case:

CASE REPORT

R. M. U., a white male, 53 years of age, was admitted to the service of Dr. Paul C. Colonna at the Hospital of the University of Pennsylvania on Sept. 19, 1943, having been thrown from a horse the day before, at which time his right foot was forced into inversion and adduction. At the time of admission the ankle was moderately swollen and extremely tender around the external malleolus and very painful on motion. There was some ecchymosis around the lateral aspect.

Anteroposterior and lateral roentgenograms showed only two small smooth fragments of bone lying in the soft tissues below the internal malleolus, which were interpreted as representing an old fracture of that part (Fig. 1).

Because the symptoms were suggestive of more than the usual sprain, the surgeons in charge of the case requested anteroposterior roentgenograms with

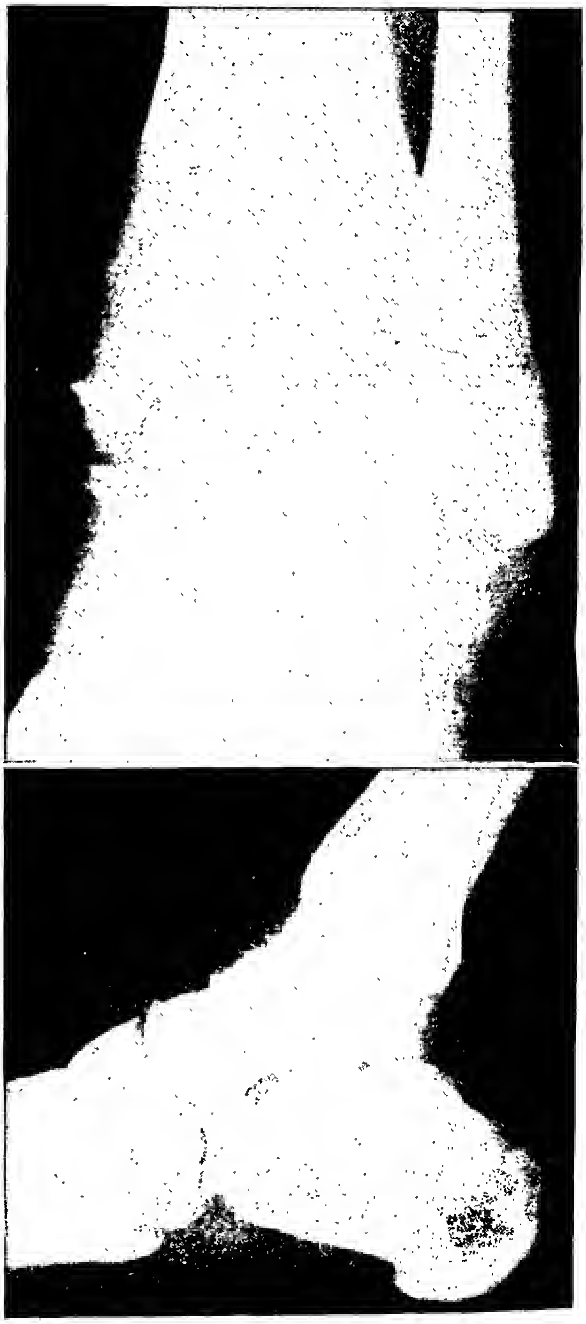

Fig. 1. Ankle at the time of injury. The anteroposterior view shows only two small fragments of the medial malleolus, which were thought to represent an old injury. The lateral view shows nothing abnormal.

[1] From the Department of Radiology, Hospital of the University of Pennsylvania, Philadelphia, Penna. Accepted for publication in November 1944.

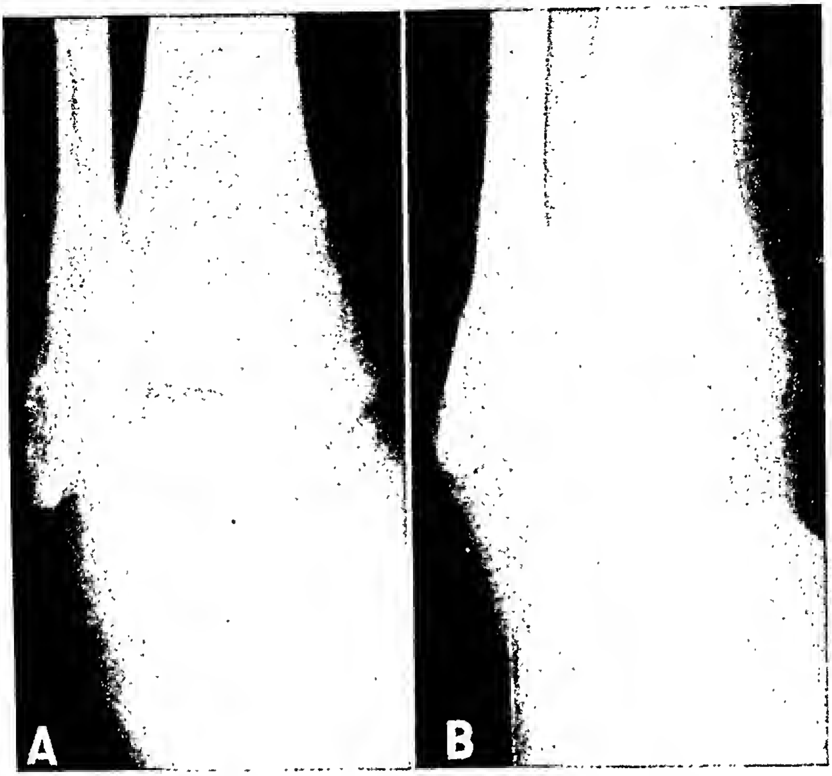

Fig. 2. A. Anteroposterior view of the foot at the time of injury, in forced inversion, showing a widening of the tibio-astragalar joint, which is the sign of tear of the lateral ligaments.
B. The foot held in forced inversion after immobilization for four weeks. There is now no widening of the tibio-astragalar joint.

the foot held in forced inversion and then in forced eversion. The study made in forced inversion showed that the talus had tilted in the ankle mortise and this had produced an increase in the joint space between the talus and the tibia (Fig. 2, A). It was felt that this indicated excessive relaxation, stretching, or tearing of the ligaments of the ankle; a report was made of a probable excess of mobility of the talus upon the tibia, and the foot was immobilized in plaster for four weeks. At the end of that time the two small fragments at the tip of the medial malleolus were unchanged, but there was no evidence of spread of the tibio-astragalar joint space on forced inversion (Fig. 2, B).

DISCUSSION

Realizing from this case how little we knew of the normal ankle when it was subjected to strain, we obtained roentgenograms of six normal ankles in inversion and eversion, and in none of these found any change in either the joint space between the talus and the tibia, or in the relationship of the tibia and fibula to each other (Fig. 3, A, B, C).

The ankle is a ginglymus or hinge joint which is made up of the lower end of the tibia and the malleoli of the tibia and fibula. These bones, with the transverse ligament, form a mortise for the upper convex surface and lateral facets of the talus. The ligaments of the joint (Fig. 4) are as follows: the surrounding articular capsule; the deltoid or internal lateral ligament; the anterior talofibular ligament; the posterior talofibular ligament; the calcaneofibular ligament. These last three are known also as the anterior, middle, and posterior fasciculi of the external lateral ligament (2).

According to Watson-Jones (3), an injury causing rupture or severe stretching of the external lateral ligament would produce a picture such as was seen in the above case, and he considers this injury a partial dislocation at the ankle joint. He recommends anteroposterior roentgenograms in forced inversion and eversion for its diagnosis (3). Elmslie also discusses

Fig. 5. C. Normal ankle in forced extension.

SUMMARY

A type of dislocation of the ankle is described in which the usual anteroposterior and lateral roentgenograms appear normal. It is due to rupture or stretching of the external lateral ligaments of the ankle joint and is demonstrable in anteroposterior roentgenograms of the ankle in forced inversion, showing widening of the tibio-astragalar joint space. Roentgenograms of normal ankles in inversion, eversion, flexion, and extension are shown for comparison. Indications for this type of examination are discussed.

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Osteogenic Sarcoma of the Skull[1]

LT. COMDR. L. H. GARLAND, (MC) U.S.N.R

PRIMARY osteogenic sarcoma of the skull is an exceedingly rare entity. Camp, in a wide experience with skull roentgenography extending over approximately twenty-five years, recollects seeing only four or five examples (1). Examination of several standard textbooks on pathology and roentgenology discloses no reported cases.

Osteogenic sarcoma of the skull secondary to long standing osteodystrophia fibrosa hyperostotica (Paget's disease) is a not uncommon entity. It is estimated that in anywhere from 2 to 10 per cent of patients with Paget's disease of the skull such a condition eventually develops. This type of malignant growth is inherently secondary rather than primary and is most likely to occur in the age period when osteogenic sarcoma is a rarity. We have seen 5 cases of osteogenic sarcoma complicating Paget's disease of the skull, all in persons over fifty-five years of age, during a ten-year period ending in 1942 (chiefly on the Stanford University X-ray Service at the San Francisco City Hospital).

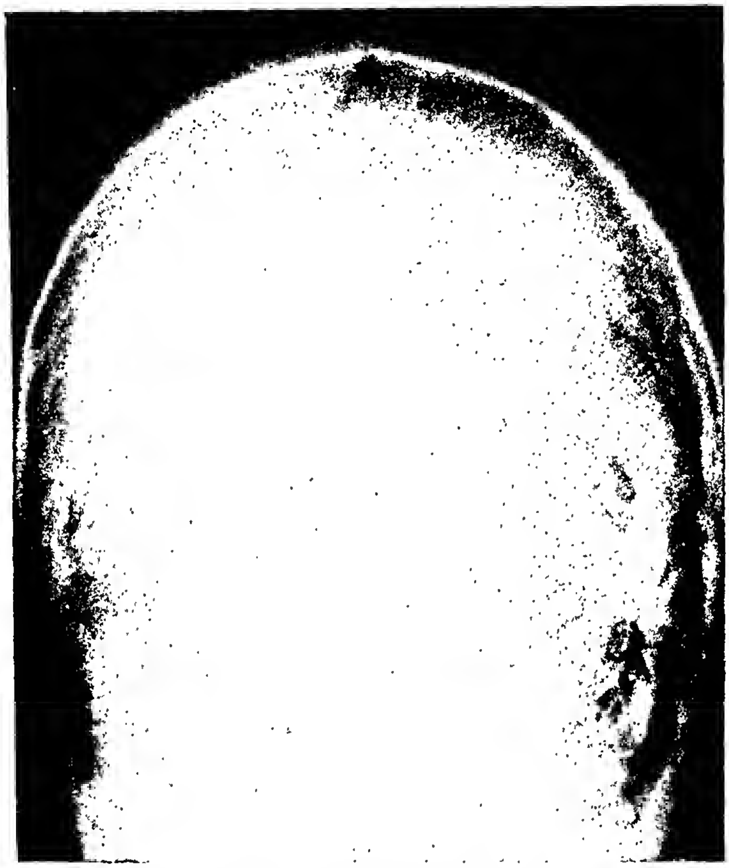

Fig. 1. Anteroposterior (occipital) projection of the skull showing irregular increase in density of the occipital bone, involving an area about 8 cm. in diameter.

Primary osteogenic sarcoma of bone is essentially a disease of the young, its incidence reaching a peak at fifteen years of age. It occurs twice as commonly in males as in females, and over 50 per cent of cases arise in one of the bones of the

[1] Accepted for publication in October 1944. The opinions expressed herein are those of the writer and are not to be construed as official or reflecting the views of the Navy Department.

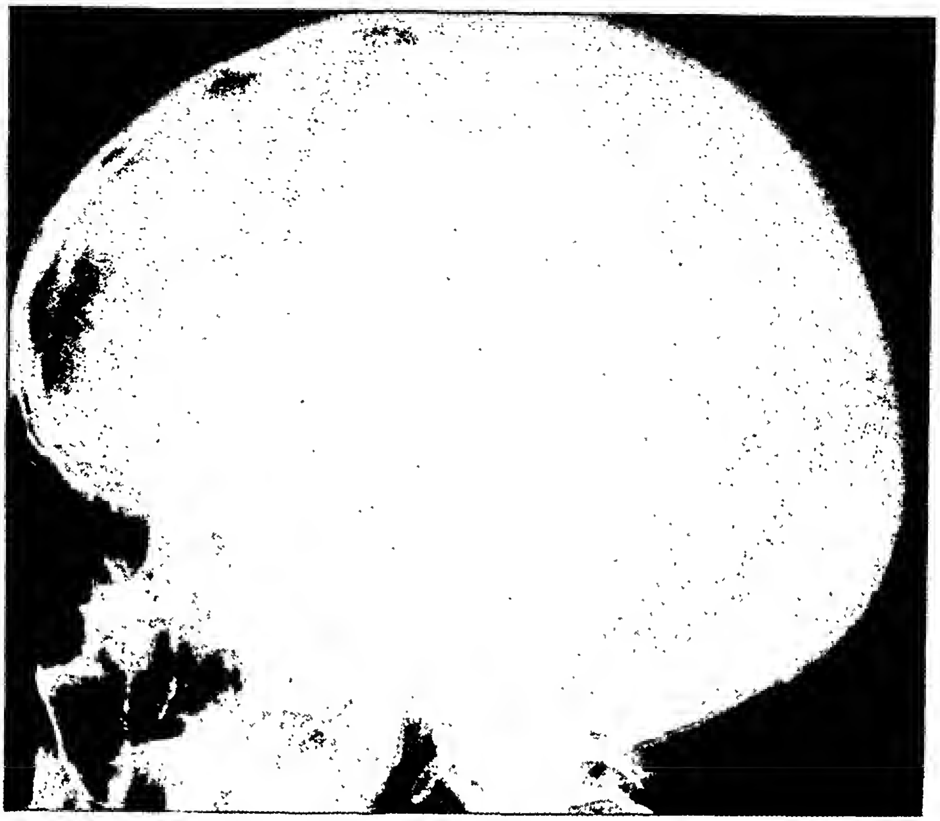

Fig. 2. Right lateral projection of the skull. The outer table alone appears to be involved.

Fig. 3. Soft-tissue lateral projection of the tumor, showing spicule formation and calcification. Microscopic diagnosis: osteogenic sarcoma.

lower extremity (2). Less than 1.0 per cent of cases develop in the skull bones. In view of this incidence, the following case is being reported.

A seaman aged 17 reported to sickbay for examination of a lump on the back of his neck, at the base of his skull. He stated that the lump had grown during the preceding two months, was slightly painful, and caused some limitation of cranial movements. Its most prominent portion lay slightly to the right of the mid-line and it felt about the size of a ping-pong ball. Except for the mass, the patient felt and appeared quite well. The surgeon who saw him made a tentative diagnosis of osteochondroma and removed the mass on Feb. 2, 1944, at a Mid-Pacific Base Hospital. The biopsy report is not available.

Recovery was prompt, and the patient returned to duty. After about eight weeks, the lump recurred and was slightly more painful than before. The patient was sent back to a Naval Hospital on the Pacific Coast, where he reported at the end of April. He was a well built and apparently healthy young male, with no complaints beyond those above described. The mass had grown to about 8 cm. in diameter and was hard and fixed. The scar from the previous operation appeared healthy. X-ray examination of the lungs was negative. The skull showed extensive thickening of the outer table of the occipital bone, chiefly to the right of the mid-line, with considerable spiculation and a small amount of irregular calcification in the tumor (see Figs. 1–3). In many respects the x-ray appearance resembled that of an endothelioma, but the bone formation was, of course, on the "wrong" side of the calvarium for such an entity. Stereoscopic lateral, oblique, and tangential projections all failed to disclose any evidence of involvement of the inner table. The roentgen diagnosis was tumor of the occipital bone, malignant, presumably some type of osteogenic sarcoma.

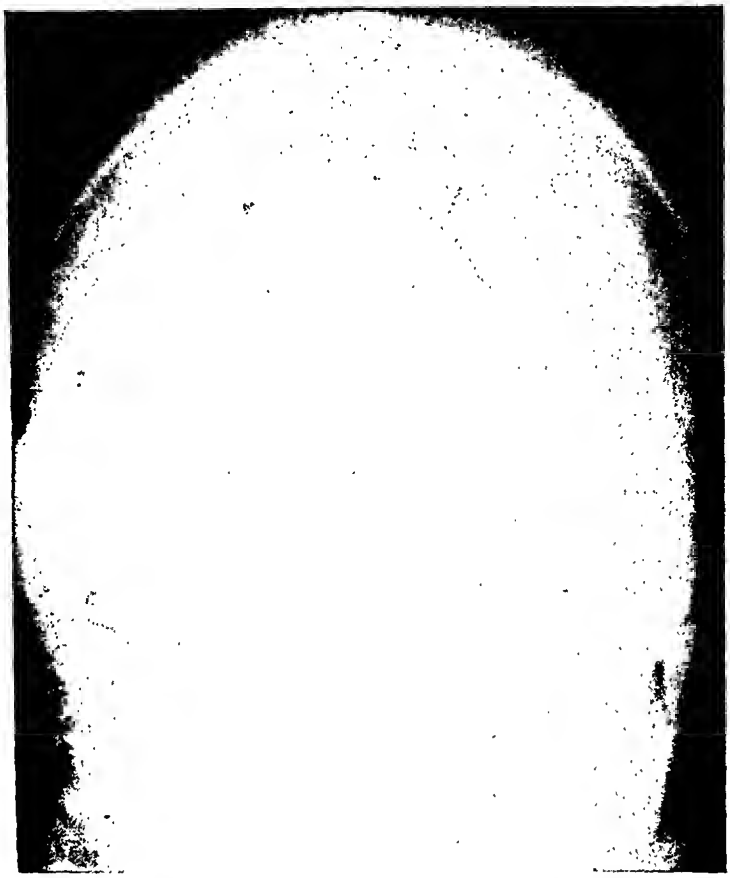

Fig. 4. Occipital projection, postoperative, showing tantalum plate *in situ*.

On May 1, 1944, Lt. Comdr. F. K. Bradford performed a radical operation, resecting most of the occipital bone. Grossly the tumor appeared to be malignant and to have invaded the muscles of the neck. The surgeon removed as much of these muscles and of the ligamentum nuchae as he dared and replaced the bone with a molded tantalum plate. The plate was attached securely to the skull, and the remaining posterior cervical muscles were then attached to the plate (Figs. 4 and 5).

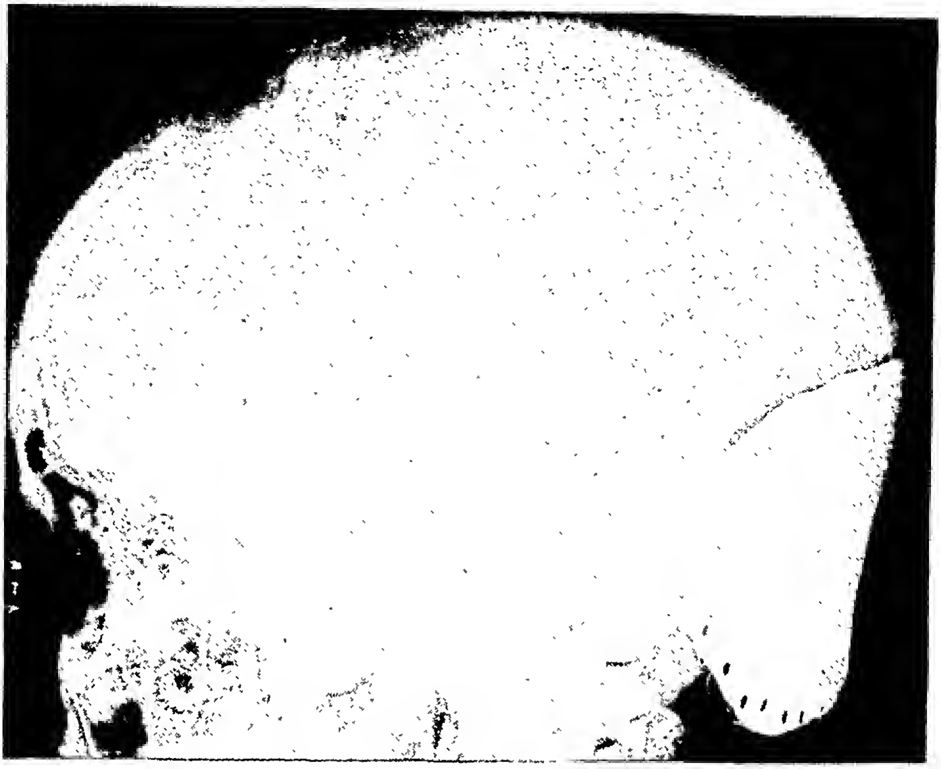

Fig. 5. Lateral projection, postoperative, showing tantalum plate *in situ*

The pathological report (by Lt. Comdr. L. H. Dyke) was as follows: The gross specimen consists of a strip of scarred skin, some subcutaneous tissue, and numerous masses of bone and muscle, all measuring 12 × 12 × 5 cm. There is a neoplastic mass 8 cm. in diameter, which has been completely excised; this contains numerous spicules of bone. Portion of the occipital bone shows infiltration of the outer table by neoplasm, but no gross infiltration of the inner table. Microscopically, the tumor is composed of pleomorphic, spindle-shaped cells, rather variable in size and shape, with fairly frequent mitotic figures; these cells infiltrate a dense supporting stroma between masses of bone. There are some areas of new bone formation and some of metaplasia, forming small islands of cartilage. Diagnosis: sarcoma, osteoblastic and osteogenic.

Immediately after the preoperative roentgen examination, a course of roentgen irradiation had been started; this was continued following operation. The patient was treated in the prone position, through one large posterior portal, 15 × 15 cm., covering the back of the skull and upper posterior neck. He was given 2,500 r (air) between April 28 and May 24, 1944, with a 200-kv. beam, half-value layer 1 mm. Cu.

Young and unusually sanguine, the patient made a rapid recovery and was discharged one month after conclusion of the roentgen irradiation course. At the time of this report, he is still clinically well, but we regard the prognosis as quite hopeless.

SUMMARY

A case of osteogenic sarcoma of the occipital bone in a male aged seventeen years is reported. The tumor was subjected to radical excision and the tumor site to fairly heavy roentgen irradiation. The rarity of tumors of this type is emphasized.

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Relationship Between Morphology and X-Ray Effects in Implants of Mouse Sarcoma 180 Irradiated with 5,000 and 60,000 Roentgens (in Air)[1]

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THE EXPERIMENT to be described in this paper deals with the morphology of implants of mouse sarcoma 180 previously irradiated with 5,000 r (in air), as compared with that of implants irradiated with 60,000 r (in air) and unirradiated controls, as they appeared during ten successive days following implantation into 100 per cent susceptible mice.

This is an extension of previous investigations in which it was demonstrated (*a*) that a dose of 60,000 r, measured in air, was required to prevent the proliferation of explants of mouse sarcoma 180 in a culture medium *in vitro* (1); (*b*) that a dose of 5,000 r was sufficient to prevent implants from producing a detectable tumor *in vivo* in a strain in which control implants were 100 per cent successful (2); (*c*) that animals implanted with tumor fragments irradiated with 5,000 r became resistant to subsequent implants of the same type of tumor, while those animals implanted with tumor fragments irradiated with 60,000 r did not (3).

Several authors (4–9) have investigated the reaction of an immune host to viable tumor implants, but there has apparently been no cytological study of tumor implants inducing resistance in 100 per cent susceptible hosts.

EXPERIMENTAL PROCEDURE

The same strain of mice (C.F.X. strain from Carworth Farms) was used here as in the previous experiments (1–3), and the experimental procedure was similar. An eight-day-old tumor was removed from the host under aseptic precautions. In order to secure actively growing cells and to avoid necrosis, only portions from the periphery of the tumor were taken for implants. With a cataract knife, fragments were cut, ranging from 1 to 2 mg. in weight, from 1.2 to 1.5 mm. in length, and from 1.4 to 0.9 mm. in thickness. These fragments were divided into three portions. Each was placed on a No. 1 coverslip, which had been previously attached to a square mica sheet, covered with a Maximow slide, and sealed with paraffin. To avoid evaporation, a fragment of moist filter paper was placed in the concavity of the Maximow slide. One portion of the tumor fragments was then irradiated with 5,000 r, measured in air without backscatter, and another with 60,000 r. The third portion, which was not irradiated, was used for a control. The physical factors were as follows: 200 kv., 20 ma., 0.5 mm. Cu + 1.0 mm. Al, half-value layer equivalent to 0.85 mm. Cu, focal tissue-target distance 12.5 cm., with a dosage rate of 612 r per min. measured in air. Immediately after irradiation, the tumor fragments were implanted into animals by means of a trocar. The chosen site for implantation was about the middle of the abdomen, between the groin and the axilla. This site was found by Russell (4) to be the most suitable, for the graft is thus placed in clean fascial tissue below the cutis, avoiding the extensive adipose tissue which is present in the axillary and groin region in the mouse. As a precaution against infection, the site of the inoculation was shaved and cleaned with alcohol and iodine. The trocar was inserted into the groin region and pushed upwards under the skin. The tumor graft was deposited

[1] From the Division of Cancer, Department of Hospitals, New York City, and the Department of Experimental Surgery, New York University Medical College. Read by title at the Twenty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 1–2, 1943.

midway between the groin and axilla by means of a plunger.

Thirty male mice about six weeks of age were divided among three separate cages, ten to a cage. Those of one group were implanted with tumor fragments irradiated with 5,000 r, those of another with tumor fragments irradiated with 60,000 r, and those of the third with non-irradiated tumor fragments. All of the mice were kept under the same conditions and received Purina dog chow and water *ad libitum*. Every twenty-four hours during ten successive days following implantation, tumor fragments were removed from three mice, one from each cage. This was done because of the previous observation that fragments of sarcoma 180 usually produced tumors about 1 cm. in diameter in ten days, while tumor fragments previously irradiated with 5,000 r produced no tumor but induced immunity which could be detected from ten days to six months after implantation, and tumor fragments irradiated with 60,000 r produced neither tumor nor resistance to subsequent implants. To avoid injury to the tumor grafts, special precautions were taken on their removal. The skin was cut through the length of the mid-abdomen and lifted up carefully, being separated from the abdominal wall and thorax with the aid of a chromium spatula. The tumor graft was then seen lying attached to the skin. Measurements of the grafts were taken by means of a caliper before their removal from the animal. The tumor graft, including the surrounding tissue of the host, was dissected with sharp scissors, lifted up with fine forceps, and immersed in Zenker's fixative. This experiment was repeated, using the same number of animals and the same technic, with similar results. The sizes of the grafts as well as their macroscopic and microscopic characteristics are recorded in the appended Protocols.

OBSERVATIONS

Macroscopically, implants irradiated with 60,000 r (in air) did not appear appreciably different from those irradiated with 5,000 r (in air). They were pale—some yellowish—and attached to the skin of the host. No vascularity could be noted within the fragments, although capillaries and blood vessels could be seen in the periphery of the inoculation site. The tumors were between 2 mm. and 3 mm. in diameter, which approximated the initial size on implantation.[2] In contrast, the control implants appeared translucent and vascularized about the fourth day, while those examined on subsequent days had increased in size.

Microscopically it was observed that after irradiation with either 5,000 r or 60,000 r the implanted cells had undergone extensive degenerative changes. Some of the cells became pyknotic, with acidophilic cytoplasm. Others, especially in the later periods, showed irregularities of nuclear form with fragmentation or the occurrence of giant nuclei. Cytoplasmic vacuolization was often conspicuous. In the last few days of observation, implants irradiated with the larger dose contained less tumor tissue than those irradiated with the smaller dose, but cell counts were not made.

Necrosis was present in the central portion of the control implants during the first three days, decreased in amount during the resumption of active growth, and increased slightly during the last three days. Some of the peripheral cells did not undergo necrosis, and mitoses were noted among them on the third and subsequent days, during which increase in size of the implant occurred.

In the implants irradiated with 5,000 r, occasional mitoses were observed during the first two days. Whether this indicates that division started after implantation, or whether divisions present during irradiation were completed after implantation, is not determined. This question is of interest in view of the discussion in the literature concerning the dependence of

[2] A more precise procedure would have been to determine the weights of the implants. This, however, could not be done, because in dissecting the implants some of the surrounding normal tissue was included in order to avoid injury to the tumor graft.

induced resistance on the active growth of the implant.

It has been generally believed that the induction of resistance to transplanted tumors may be attributed either (*a*) to the growth or growth substances of the implanted tissue or (*b*) to its degenerative products. According to the observations made from this study, neither growth of the implant nor necrosis of its cells can alone account for the induction of resistance. The latter is clear from the failure of implants irradiated with 60,000 r to induce resistance, although necrosis is extensive. The former is suggested by the experiments of Sugiura (10) and others, who excised growing implants of sarcoma 180 and Flexner-Jobling rat carcinoma and found that resistance to subsequent implants had not been induced. Whatever induces resistance is operative after a dose of 5,000 r (in air) but not after 60,000 r (in air).

SUMMARY

After irradiation with 5,000 or 60,000 r (in air), implants of mouse sarcoma 180 showed no increase in size during ten successive days. Extensive degenerative changes were observed in the tumor cells, including nuclear pyknosis and fragmentation and cytoplasmic vacuolization. Tumor giant cells with pronounced cytoplasmic changes were often conspicuous.

Cytologic differences between the cells of implants irradiated with 5,000 r and with 60,000 r were not detected. During the last few days of observation the implants previously irradiated with 60,000 r contained a smaller amount of tumor tissue than those irradiated with 5,000 r.

Evidence that active growth occurred in the tumor implants irradiated with 5,000 r, which had previously been shown to induce resistance, was not observed.

PROTOCOLS

Macroscopic and Microscopic Characteristics of Implants During Ten Successive Days, Following Irradiation with 5,000 r (in air)

First Day: The tumor implant, measuring about 2 × 2 mm., slightly attached to the skin and imbedded in a gelatinous mass, was excised. Microscopic sections consisted of tumor, muscle, and fat. Tumor cells were seen in two sites: in the center of a pad of fat and at its periphery. (1) In the center of the pad of fat, they appeared as individual cells accompanied by a few leukocytes. These tumor cells showed no pyknosis. The nuclei had a distinct membrane and discrete chromatin particles; a few had prominent nucleoli. An occasional cell was binucleated, and an occasional one was in mitosis. In some, minute vacuoles appeared in the cytoplasm, sometimes limited to one part of the cell. These vacuoles were seen, also, in dividing cells. (2) At the periphery of the fat pad a few tumor cells were seen, surrounded by leukocytes. The tumor cells here showed pyknosis and nuclear details were not distinct. The chromatin particles were similar and more diffuse. Nucleoli were present, but indistinctly stained.

Second Day: The tumor implant, about 2 × 2 mm., appeared opaque, imbedded in a gelatinous mass attached to the skin. The microscopic picture showed a large necrotic mass with tumor cells at the periphery. The nuclei were often of irregular form. The cytoplasm was fairly abundant, sometimes vacuolated. An occasional mitotic figure was observed. In the tumor cells, nuclei tended to stain diffusely, with fewer discrete chromatin particles than in those of the first day. This was particularly noticeable near the central part of the necrotic area, where the cells became smaller and more pyknotic, and many underwent disintegration. There was an inflammatory reaction in the surrounding tissue, but this was not very intense.

Third Day: A 3 × 3-mm. tumor implant, pale, imbedded in a gelatinous mass, was dissected. The microscopic picture showed tumor, muscle, and adjacent fat tissue. The tumor cells were few and accompanied by edema and inflammatory reaction. They showed degenerative changes in the form of irregular nuclei, with diffuse nuclear staining and indistinct discrete chromatin particles. Vacuolization of the cytoplasm was prominent. Mitosis was not observed.

Fourth Day: The implant, approximately 2 × 2 mm., appeared opaque, imbedded in a gelatinous, non-vascular mass. Microscopic sections showed a fragment of tissue containing tumor giant cells, inflammatory corpuscles, and necrosis. The tumor cells all showed degenerative changes. Most had irregular nuclei or several nuclear lobes. The chromatin was finely divided, the nuclei often deeply stained. In some cells several small nuclear particles were seen. There was also vacuolization of the cytoplasm.

Fifth Day: The tumor implant, about 3 × 2 mm., appeared pale, but the gelatinous mass in which it was imbedded was vascular. Microscopic sections showed necrosis, with a chronic granulomatous inflammation in the surrounding tissue, containing large numbers of tumor giant cells. These

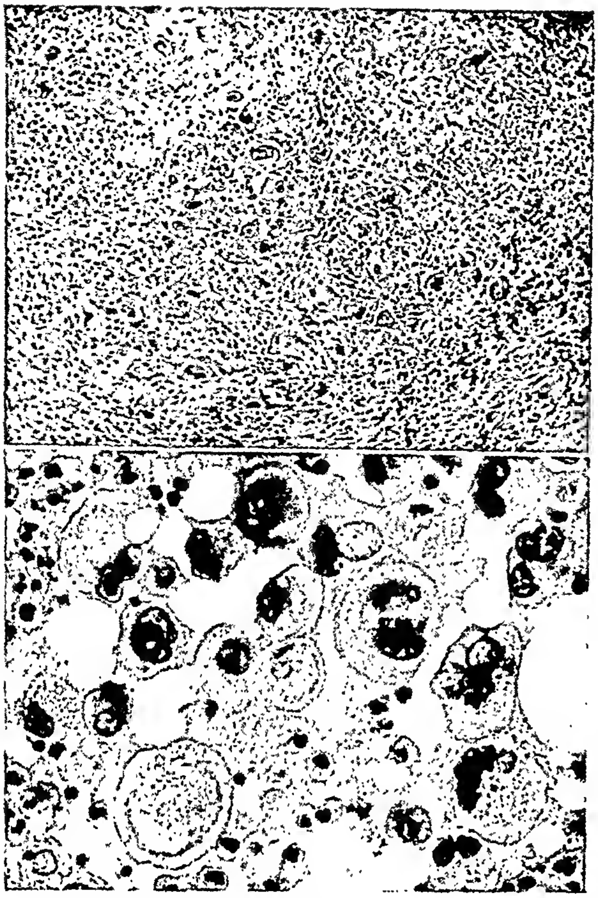

Fig. 1 (above). Tumor implant of sarcoma 180 six days after irradiation with 5,000 r (in air). Note the irregular shape of the nuclei of the sarcoma cells, the fragmentation of the chromatin substance, and the cell with the three-lobed nucleus. Hematoxylin and eosin. ×90.

Fig. 2 (below). Tumor implant eight days after irradiation with 5,000 r (in air). Note the swelling of the sarcoma cells, vacuolization of the cytoplasm, and nuclear irregularities. Hematoxylin and eosin. ×185.

tumor cells had sometimes a single nucleus and sometimes many nuclei. The nuclei were deeply stained. Only an occasional cell had a vesicular nucleus. Nucleoli were relatively prominent. Cytoplasm was abundant and often vacuolated. Mitotic figures were not observed in the tumor cells, but were present in the cells of the surrounding granulation tissue. In the cells with several nuclei, the appearance was often one of bleb formation, some of the blebs having been separated by constriction. Bleb formation of the cytoplasm was also occasionally seen.

Sixth Day: The implant, about 2 × 2 mm., was pale and attached to the skin. No blood vessels could be discovered in the immediate area. Microscopically there was seen a small mass of tissue, mainly granulation tissue, containing a large number of tumor cells. In many tumor cells the nucleus was vesicular, often irregular in shape; many showed chromatin fragmentation, while others had several small nuclear lobes. Cytoplasmic vacuolization was pronounced.

Seventh Day: The implant, about 2 × 2 mm., was firmly attached to the skin, opaque and pale. Microscopically, the mass of tissue was seen to contain numerous tumor cells, surrounded by mononuclear cells, some of which appeared to be phagocytes. Around this was an area of mild granulomatous inflammatory reaction, containing a few fragments of hair and foreign-body giant cells. All the cells showed degenerative changes of some type. Nuclear irregularities, with the formation of lobules or separate small nuclear fragments, were common. Pyknosis was present in some cells; others had vesicular nuclei, but with chromatin fragmentation. Nucleoli were only occasionally distinct. Cytoplasmic vacuolization was a prominent feature, and in many cells resulted in "foamy" cytoplasm. No mitoses were seen.

Eighth Day: The tumor implant, 3 × 2 mm., appeared opaque and pale, though it was surrounded by some blood capillaries. Microscopically a large mass of granulomatous tissue was seen, with a small amount of necrosis in the center. There were numerous tumor cells throughout the mass, showing various degenerative changes, including vacuolization of the cells and an occasional structure resembling an intranuclear inclusion. There were marked degenerative changes, as on the seventh day. The enlargement and vacuolization of the cytoplasm often produced large "foam" cells. Mitotic figures were not observed.

Ninth Day: The implant was pale and opaque, about 3 × 2 mm. The microscopic picture showed a mass of granulation tissue, in the center of which necrotic tissue appeared infiltrated with leukocytes. In the periphery, the cells were mainly of mononuclear type, although leukocytes were still present. In this mass, particularly in the mid-zone, were a number of very large tumor cells, some multinuclear, which apparently showed degenerative changes in the form of vacuolated cytoplasm, shreddy cytoplasm, and changes in nuclear shape. Some of the nuclei contained a single distinct rod-like nucleolus. Others were vesicular. Mitotic figures were not observed. An occasional foreign-body giant cell was also noted. An inflammatory reaction extended for a short distance into the neighboring muscle.

Tenth Day: The tumor implant, about 2 × 2 mm., was pale and opaque. The microscopic sections showed chiefly fibroblasts, mononuclear cells of various types, and occasional lymphocytes. Among these were a number of isolated large tumor cells, sometimes mononuclear, sometimes polymorphonuclear. The nuclei were occasionally hyperchromatic; some were greatly elongated. The cells themselves were often elongated, with cytoplasmic processes. Marked acidophilia of the cytoplasm was observed in a few of them. There was a distinct tendency for the large tumor cells to become elongated and to show pyknosis. Pyknosis was also ob-

served in several large polygonal tumor cells. There were no mitotic figures among the tumor cells.

Macroscopic and Microscopic Characteristics of Implants During Ten Successive Days Following Irradiation with 60,000 r (in air)

First Day: The implant, about 2 × 2 mm., was imbedded in a gelatinous mass. Microscopic sections showed necrotic tissue, with fragmentation of nuclei and leukocytic infiltration. There were isolated large tumor cells showing degenerative changes.

Second Day: The tumor implant, about 3 × 2 mm., was opaque, pale, and attached to the skin in a gelatinous mass. Microscopic sections showed necrotic tumor tissue, with dense leukocytic infiltration and nuclear fragmentation. At the periphery were a few tumor cells with slight pyknosis of the nuclei, distinct nucleoli, and moderate cytoplasmic vacuolization.

Third Day: The tumor fragment, measuring about 3 × 2 mm., was pale and attached to the skin. The microscopic picture showed a small piece of fat tissue with foci of tumor cells surrounded by inflammatory reaction. The tumor cells varied considerably in size and shape; some of the smaller ones were distinguished from fibroblasts with difficulty. The larger ones showed nuclear fragmentation or had very granular chromatin and loss of nucleoli. The cytoplasm of many tumor cells was vacuolated. Most of them were mononuclear, but a few were polymorphonuclear.

Fourth Day: The implant, about 3 × 2 mm., was pale and attached to the skin. Some of the microscopic sections showed only inflammatory reaction, consisting mainly of leukocytes and mononuclear cells. One of the slides showed, in addition, areas of necrosis; near these, and in them, were isolated cells which suggested tumor cells. They were large, irregular in shape, and some of them were hyperchromatic. Mitoses were not present.

Fifth Day: The implant, about 3 × 2 mm., appeared yellowish and opaque and was attached to the skin. Blood capillaries were not observed in the immediate area. The microscopic sections consisted of chronic inflammatory tissue, in which were several isolated, large, bizarre mononuclear and polymorphonuclear tumor cells. In some of the tumor cells the nuclear network was distinct, often granular. Some nuclei showed diffuse staining, and some had nuclear blebs or separate nuclear fragments. The cytoplasm was markedly vacuolated. An occasional giant tumor cell, with several nuclei, was seen. No mitotic figures were observed.

Sixth Day: The tumor implant, 2 × 2 mm., appeared pale and was attached to the skin. No blood vessels could be seen in the surrounding area. The microscopic sections consisted of granulation tissue in which degenerating tumor cells were seen. The large tumor cells were of irregular shapes, with polymorphous nuclei, occasionally with distinct nucleoli. In a few, the nucleus was hyperchromatic.

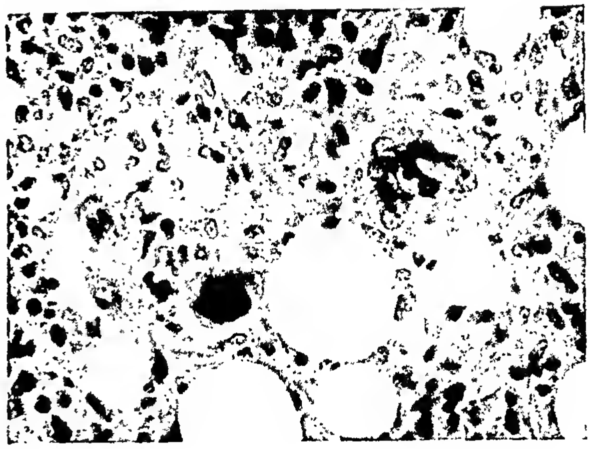

Fig. 3. Tumor implant six days after irradiation with 60,000 r (in air). Note the large irregular sarcoma cells, the polymorphous nuclei, and the vacuolated cytoplasm. Hematoxylin and eosin stain. ×185.

The cytoplasm showed small and large vacuoles. The surrounding inflammatory reaction consisted of a few leukocytes, but mostly small mononuclear cells and fibroblasts. This involved some of the surrounding striated muscle.

Seventh Day: A pale implant, about 2 × 1.5 mm. in size, attached to the skin, was dissected. Microscopically it consisted of a few very large cells, of bizarre form, surrounded by a chronic inflammatory reaction. The nuclei of these cells were larger, and the chromatin particles coarser, than in the normal tumor cells; some of the nuclei were polymorphic. Nucleoli were present, but only occasionally prominent. Other changes included pyknotic or granular nuclei, loss of nucleoli, and vacuolated cytoplasm.

Eighth Day: In size and macroscopic appearance the implant was similar to those previously described. Microscopic sections showed a minute nodule in which a few very large, bizarre tumor cells were seen. With these cells was a fibroblastic reaction forming a small granuloma, in the center of which a few foreign bodies were seen. The tumor cells showed nuclear granularity, with loss of nucleoli in some, and enlargement with irregular shape in others. In a few there was complete nuclear disintegration. Cytoplasmic vacuolization was pronounced.

Ninth and Tenth Days: The macroscopic and microscopic appearances of the implants on the ninth and tenth day following implantation were similar to those previously described. All tumor cells showed pyknosis or poorly stained nuclei, vacuolated and distintegrated cytoplasm. No mitotic figures were noted.

Macroscopic and Microscopic Characteristics of Unirradiated Control Implants During Ten Successive Days

First Day: The implant, about 2 × 2 mm., was imbedded in an opaque, gelatinous mass. In the

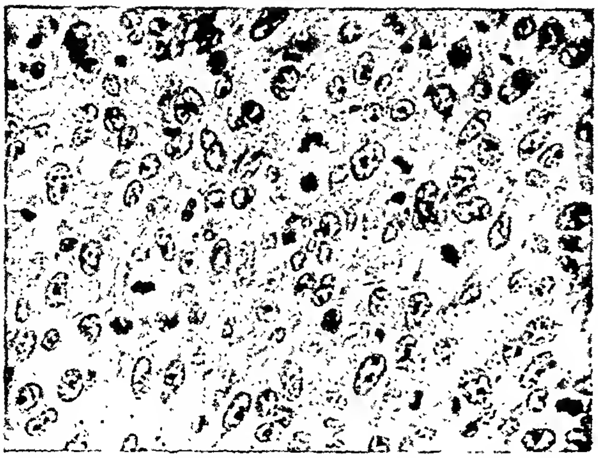

Fig. 4. Section of a tumor produced by a control non-irradiated implant. Note the numerous mitotic figures and the abunpance of actively growing cells, in contrast to the previous figures. Hematoxylin and eosin stain. ×185.

serial sections, the tumor cells showed varying degrees of nuclear hyperchromatism, the most marked changes resulting in small, densely stained nuclei. There was a progressive loss of the nucleoli as these changes became more marked. The cytoplasm was often vacuolated, and in some instances contained fragments of eosinophilic material. In cells with the greatest nuclear changes, the cytoplasm had become homogeneous and deeply eosinophilic. In addition, some cells showed karyolytic changes resulting in faintly stained "ghost-like" remnants. No mitoses were observed.

Second Day: The implant was attached to the skin, surrounded by an opaque, gelatinous mass, in which a few blood capillaries could be seen. Microscopically, there could be noted a necrotic portion of the tumor implant, inflammatory corpuscles, granulation tissue, and a few tumor cells at the periphery. The morphologic appearance of the tumor cells was similar to that on the first day.

Third Day: The implant, about 3 × 3 mm., was attached to the skin and surrounded by a gelatinous, vascular mass. In the central area the cells were completely necrotic. The outer zone of tumor tissue contained well preserved cells; many were elongated, with long cytoplasmic processes. Except for this difference in shape, there was considerable uniformity in their appearance. The nuclei were vesicular, with distinct nuclear membranes. Chromatin particles were, in general, small and were often more prominent in the peripheral areas than in the center of the nucleus. There was usually one prominent nucleolus, which was round or elongated. There were approximately two mitoses per high-power field in the center zone of the implant. Giant cells were present, but not conspicuous.

Fourth Day: The implant, about 3 × 3 mm., appeared transparent, surrounded and penetrated by blood capillaries. Microscopically there could be seen a mass of tumor tissue with a large central necrotic area. The tumor cells showed a number of mitotic figures, as well as multinucleated giant cells. The tumor cells infiltrated the surrounding fat in a rather diffuse manner. There was a moderate amount of edema.

Fifth Day: The implant, about 4 × 3 mm., was transparent and vascular. Serial sections showed tumor tissue with a necrotic area in the center. A number of fibroblasts were seen around the tumor.

Sixth Day: The implant, about 4 × 4 mm., appeared transparent and vascular. The microscopic sections showed chiefly well preserved tumor cells. Mitotic figures were present. There was a moderate infiltration of leukocytes and lymphocytes within the tumor. In the center was a small area of necrosis.

Seventh Day: The tumor, about 8 × 6 mm., appeared vascular. It was attached to the skin but was easy to remove. Microscopically there could be seen a mass of tumor tissue with a necrotic center. At the edge of the necrosis there were numerous fibroblasts. The tumor cells occasionally had giant forms. Mitotic figures were present.

Eighth Day: The size of the tumor was 9 × 6 × 5 mm.; it was vascular, encapsulated, and easy to remove from the skin. The microscopic picture showed a compact mass of tumor cells, varying slightly in size and appearance. Most of the cells were somewhat irregular in shape and were slightly separated, with cytoplasmic processes. The nuclei were moderately clear, with distinct nuclear membranes and a number of small chromatin particles. The nucleoli were sometimes, but not always, fairly distinct. Mitotic figures were numerous. The cytoplasm was slightly stained with eosin; staining was in some instances more distinct near the nucleus than at the periphery. In a few areas there was focal necrosis, in which the tissue had undergone degeneration, and numerous small irregular nuclear fragments were seen. The cells at the periphery of the necrotic area showed degenerative changes in the form of pyknosis of the nucleus and increased acidophilia of the cytoplasm. Occasional vacuoles in the cytoplasm were seen in these areas, and small round acidophilic globules were present in some of the vacuoles. The tumor infiltrated the surrounding fat tissue.

Ninth and Tenth Days: The tumors at the ninth and tenth days after implantation into the animals varied between 0.9 and 1.0 cm. in diameter. The microscopic pictures were similar to that on the eighth day.

The four photomicrographs which are included in this paper serve as typical examples to illustrate the cellular appearance of the implants irradiated with 5,000 r (in air), 60,000 r (in air), and the unirradiated controls.

My grateful appreciation is herewith expressed to Dr. G. L. Rohdenburg, Director of Laboratories, Lenox Hill Hospital, New York, formerly associated

with the Crocker Institute of Cancer Research, Columbia University, for the interpretation of the histological sections and for valuable criticism and advice. I am also indebted to the Radiation Therapy Department, Bellevue Hospital, for kind cooperation and to Dr. Hugo Brach for helpful laboratory assistance.

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X-Ray Growth Zone Studies in the Rat Tail for the Appraisal of Chondrotropic Effects[1]

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INDICES OF growth commonly are determined by the size and weight of the experimental animal without reference to the specific components contributed by the separate organs or tissues of the body. Growth hormones in the past have been appraised by their effect on body weight, whereas better standardization might have been obtained by the use of tables based on observations of the "growth mechanism" of bones. The effect of hypophysectomy, causing cessation of cartilage plate proliferation, had been recognized, but not until it was re-emphasized by such observers as Freud, Levie, and Kroon (9), was it made clear that the terms "growth hormone" and "chondrotropic hormone" should be used synonymously.

The histologic study of chondrotropic effects in bone growth zones can be a long or a tedious procedure, while the x-ray examination of growth acceleration or arrest, without sacrifice of the growing parts to histologic study, can be accomplished rapidly. If both methods were to be combined, as Guerrant and Dutcher (10) actually have done in their "line test" examinations of rat tails, perhaps the optimum amount of information could be obtained. Levie (12) used the roentgen examination of the rat's tail for studying bone growth, but his standards and growth tables leave much to be desired. By a thorough reinvestigation of this method, it was our hope that a more reliable x-ray index of normal bone growth could be established as a reference for the assay of growth hormones or for the appraisal of abnormal bone growth due to any cause.

METHOD

Accurate measurements of tail length were made directly from the x-ray film; this was possible because the rats were placed in the supine position with the tail next to the film to prevent distortion. To get the best detail, the exposure time was reduced to 1/20 of a second, and fine-grain screens, a small cone, and a film-target distance of 48 inches were used. Some exposures were made without screens, but these films were not found superior enough in detail to make up for the advantage of better contrast offered by the use of screens. Of prime importance in the demonstration of all the growth zone details are films which have the proper density of exposure.

The reproductions in this paper, particularly Figure 3 show the characteristics of both properly and improperly exposed films. Errors of overexposure, if not too great, can be compensated by variations in the intensity of light in the viewing apparatus, whereas even slight degrees of underexposure result in films which fail to reveal the finer details in structure and outline of both bone and cartilage plates.

In counting the number of tail segments, the first proximal segment was designated as that one just distal to a line drawn through the lowermost margins of the ischii. The sacro-caudal segments in this area often appear slightly distorted because of the hyperextension which occurs at this level of the spine when the rat is held supine against the film. This sometimes not only makes selection of the first tail segment difficult, but also interferes with good visualization of the structural details. Some distortion of this area in the lateral view also is unavoidable, because the spine in the tail is not in the same plane with the dorso-lumbar spine when the animal is placed in this position. The use of light ether anesthesia, as practised

[1] From the Medical Research Laboratory of the Samuel S. Fels Fund, Philadelphia, Penna. Accepted for publication in November 1944.

by Levie (12), was not found necessary, because of our use of a short exposure time.

More than 1,200 rats were examined for this investigation. By the kind permission of the Wistar Institute, their entire colony was studied. This afforded us data on different litters of various ages. Similar Wistar stock rats in our own laboratory were studied daily from birth until two years of age, in order to round out the sources of our data.

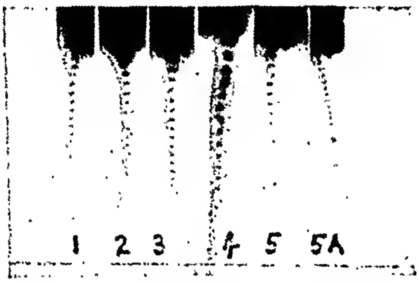

Fig. 1. Rat tail growth during first 5 days after birth. Daily length increments average 3.0 mm., but vary from 1.5 to 4.5 mm., depending on the size of the animal at birth and on the modifications in growth rate due to hereditary, dietary, and seasonal factors.

RESULTS

Day of Birth: The tails average 1.5 to 2.0 cm. in length, and the number of calcified tail segments varies from 7 to 9. The 2 proximal segments each have two unfused primary centers of ossification. The cephalic bodies are quadrilateral and become progressively flatter distally until the terminal 2 or 3 resemble thin transverse lines.

Second Day: There are 10 or 12 calcified segments, and the length of the tail varies from 1.8 to 2.3 cm.

Third Day: The number of calcified segments varies from 14 to 16, and the tail length from 2.0 to 2.7 cm. Thin transverse lines often are seen through the middle of the proximal 3 bodies, which also have transverse processes.

Fourth Day: The number of calcified segments totals 15 to 17, and the tail length varies from 2.5 to 3.1 cm. A thin transverse line may be seen in the proximal 4 or 5 bodies. The primary centers of ossification of the proximal 2 segments are fused.

Fifth Day: There are 17 to 19 calcified segments in the tail, which varies from 2.7 to 3.3 cm. in length. Mid-transverse body lines may be seen in the proximal 5 or 6 segments.

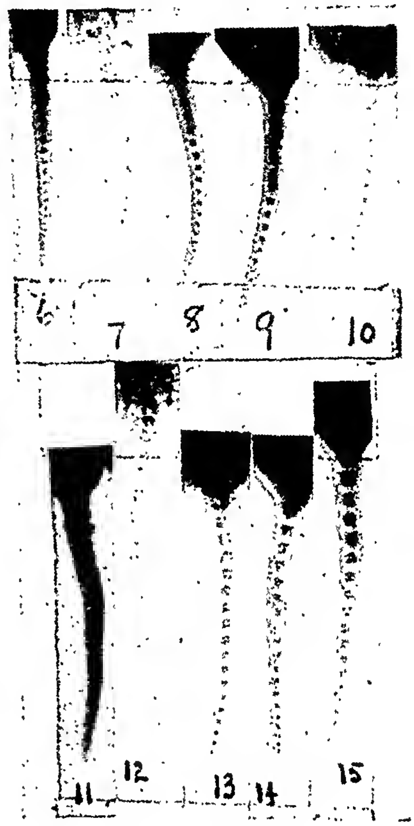

Fig. 2. Rat tail growth between the 6th and 15th day.

Sixth Day: The tail ranges from 2.9 to 3.6 cm. in length and contains 18 to 20 calcified segments. A mid-transverse line or a central minute calcified nucleus appears in each of the proximal 6 to 10 bodies.

Seventh Day: The tail is comprised of 20 to 22 calcified segments and varies from 3.3 to 4.0 cm. in length. Mid-transverse lines or central nuclei are visible in the cephalic 8 bodies.

Eighth Day: Twenty-one to 23 calcified segments are visible, and the length of the tail ranges from 3.7 to 4.2 cm. A calcified central nucleus or a mid-transverse line is discernible in the proximal 8 or 9 bodies.

Ninth Day: The length of the tail varies

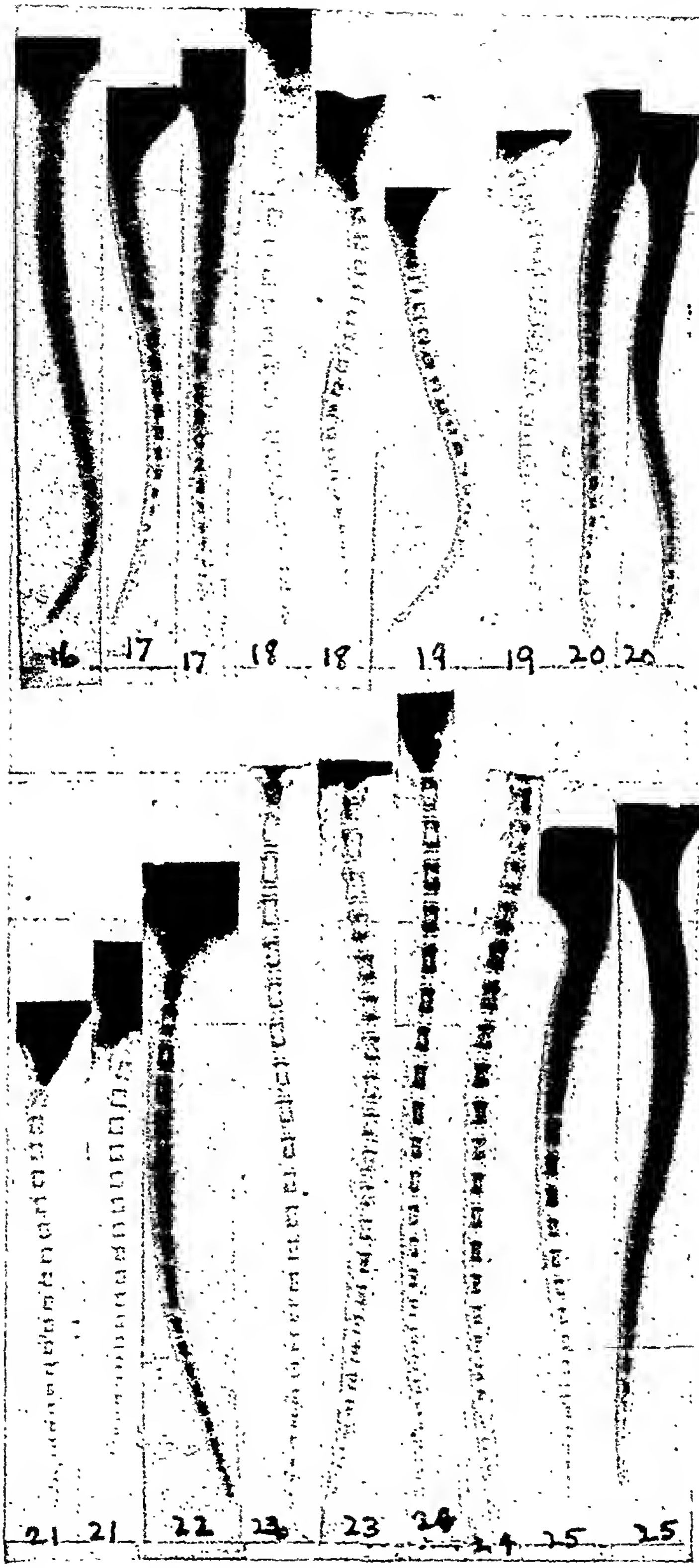

Fig. 3. Rat tail growth between the 16th and 25th day. Between the 16th and 20th day, secondary centers of epiphyseal ossification have appeared at either end of the proximal 8 to 12 bodies and appear on one additional succeeding distal segment almost daily thereafter. Between the 21st and 25th day, duplicated secondary centers are clearly visible on the bodies of the proximal half of the tail; and the more proximal of these duplex centers tend to fuse with each other. The cartilage plates are thickest during this period.

from 4.2 to 4.6 cm. and 22 calcified segments may be visible.

Tenth Day: Twenty-three calcified bodies may be seen, and the tail is 4.4 to 4.9 cm. in length. A mid-vertical instead of a mid-transverse line or a central nucleus may be seen in the proximal 8 bodies.

Eleventh Day: The tail length varies from 4.6 to 5.0 cm., but it is comprised of not more than 23 calcified segments.

Twelfth Day: Twenty-four calcified segments are present, and some semblance of a cancellous structure is visible in the proximal 8 to 10 bodies. The tail length varies from 4.9 to 5.3 cm.

Thirteenth Day: The tail length ranges from 5.1 to 5.7 cm., and the number of calcified segments varies from 23 to 25.

Fourteenth Day: Calcified segments number 25, and a central nucleus or cancellous lines can be visualized in the proximal 18 segments. The tail varies from 5.3 to 6.1 cm. in length.

Fifteenth Day: The tail ranges from 5.4 to 6.5 cm. in length and is comprised of 24 to 26 segments. In about 10 per cent, faint calcification of secondary centers of epiphyseal ossification appear at either end of the proximal 2 or 3 bodies. Each of these centers is comprised of two separate nuclei as seen in the anteroposterior view. Longitudinal cancellous lines are visible in the bodies of the proximal 12 to 14 segments, and central nuclei in the succeeding 4 to 6 bodies.

Sixteenth Day: The tail length varies from 5.5 to 6.7 cm., and the number of calcified bodies from 25 to 27. In about 15 per cent of rats, secondary centers of epiphyseal ossification are visible at either end of the proximal 3 or 4 bodies, each comprised of two separate nuclei.

Seventeenth Day: The tail measures 5.6 to 7.2 cm. in length, the number of calcified segments totals 25 to 27, and duplicated secondary centers of epiphyseal ossification are present in the proximal 5 segments in about 50 per cent of the rats. Two apophyseal centers are visible near the distal ventral corners of each of the proximal 3 bodies, best seen in oblique or lateral views. Cancellous architecture may be seen in the proximal 12 to 20 bodies.

Eighteenth Day: The number of calcified bodies in the tail is 25 to 27, and secondary centers of epiphyseal ossification are seen in the proximal 5 to 7 segments. These centers are usually duplicated, although those of the proximal 2 bodies may be fused with each other to form a single thin plate. Distal ventral apophyses are present in the cephalic 3 segments, and the tail length ranges from 5.7 to 7.5 cm.

Nineteenth Day: The tail measures 5.9 to 7.8 cm. in length and there are 25 to 27 calcified segments. Duplex centers of epiphyseal ossification are present at either end of the proximal 8 to 12 bodies. The more proximal of these tend to form a single plate by fusion with each other. Cancellous structure is more definite in the proximal bodies, and this is better seen usually in the lateral view.

Twentieth Day: The length of the tail averages 6.0 to 8.3 cm., and the number of bodies with secondary centers of epiphyseal ossification is from 10 to 12. The proximal bodies are taking on a more adult form and the vertical and transverse body lines are often duplicated, indicating the beginning of adult cancellous architecture.

Twenty-first Day: The tail is comprised of its maximum number of calcified segments, 26 to 28. Secondary centers of epiphyseal ossification are visible in the proximal 10 to 14 bodies and the distal 5 to 7 are duplicated. The bodies now tend to lose their straight contours and to become slightly biconcave along their longitudinal margins. The tail length ranges from 6.1 to 8.5 cm.

Twenty-second Day: The length of the tail varies from 6.3 to 8.9 cm. and the number of bodies with secondary centers of epiphyseal ossification from 12 to 16. The tail otherwise has the same characteristics as on the 21st day.

Twenty-third Day: The tail has now lengthened to 6.6 to 9.3 cm., and 13 to 17 proximal bodies bear secondary centers of epiphyseal ossification.

Twenty-fourth Day: The tail measures

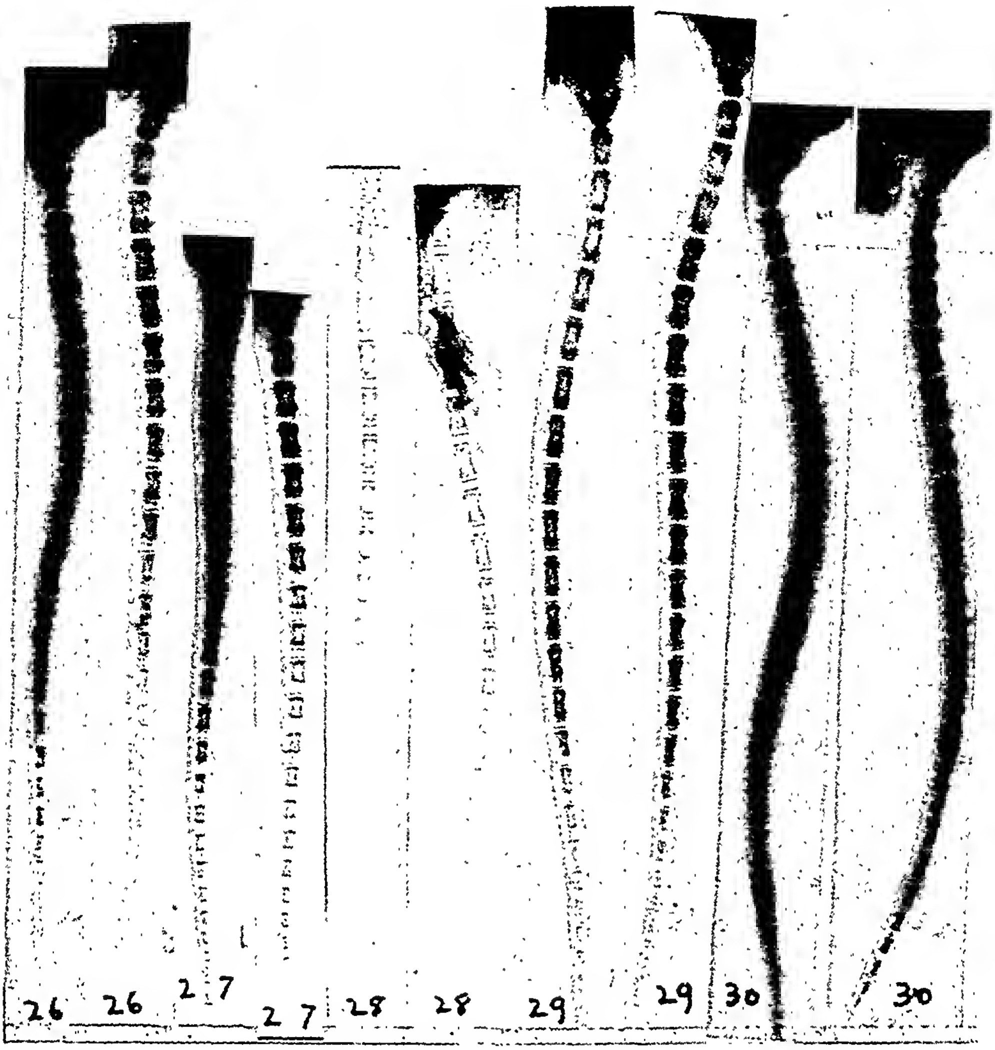

Fig. 4. Rat tail growth between the 26th and 30th day. Fusion has occurred in all the duplex centers of epiphyseal ossification except those on the distal 2 or 3 bodies, where they have but recently appeared.

7.1 to 9.7 cm. in length, and 14 to 18 proximal bodies bear secondary centers of epiphyseal ossification.

Twenty-fifth Day: The appearance of the tail is similar to that of the 24th day, but its length has increased to 7.3 to 9.8 cm. The cortex of the proximal bodies begins to get thicker.

Twenty-sixth Day: The number of bodies with secondary centers of epiphyseal ossification has increased to 16 to 20, and the centers in more than half of the proximal segments have fused with each other to form single thin plates.

Twenty-seventh Day: The tail is 7.9 to 10.5 cm. in length; otherwise it resembles the tail of the 26th day.

Twenty-eighth Day: The number of bodies with secondary centers of epiphyseal ossification is 17 to 21, and the tail length is 8.2 to 11.0 cm.

Twenty-ninth Day: There are 19 to 23 bodies with secondary centers of epiphyseal ossification, and the tail ranges from 8.5 to 11.5 cm. in length. The bodies have an adult configuration, and in those of the proximal half of the tail distinct cancellous structure may be seen.

Thirtieth Day: The tail measures 9.0 to 12.0 cm. in length; otherwise, it has a similar appearance to the tail of the 29th day.

Thirty-second Day: The tail measures 9.5 to 12.4 cm. in length, and there is dis-

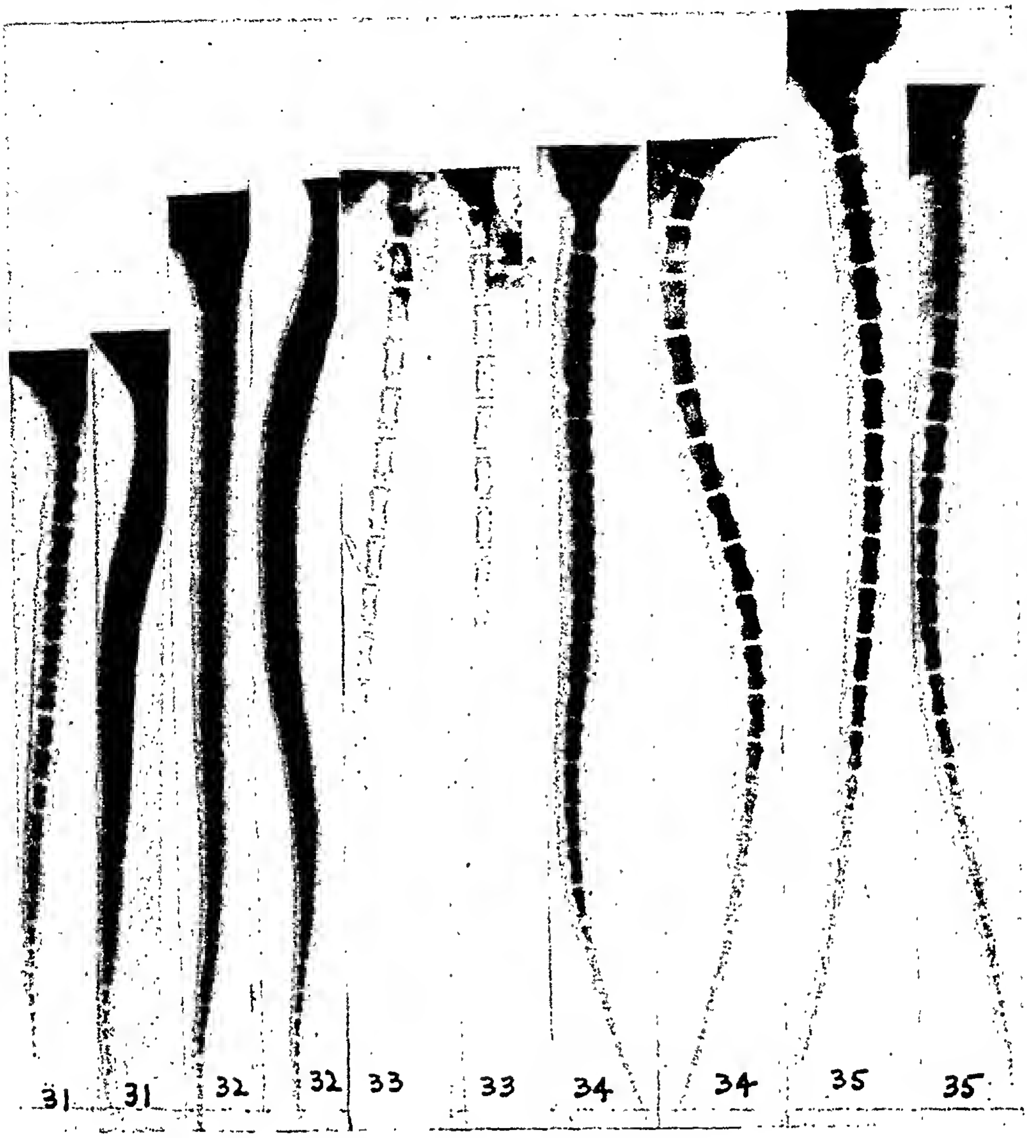

Fig. 5. Rat tail growth between the 31st and 35th day.

tinct cancellous structure in the more proximal bodies.

Thirty-fifth Day: The tail length varies from 9.7 to 13.5 cm., and the number of bodies with secondary centers of epiphyseal ossification ranges from 21 to 23. Only the secondary centers of the distal 3 or 4 bodies remain duplicated. The margins of the bodies appear more concave in the lateral view than in the anteroposterior view; and in the lateral view, the ventral margin of each body is more concave than the dorsal margin.

Fortieth Day: The tail is 10.7 to 14.7 cm. in length, and the number of bodies with secondary centers of epiphyseal ossification varies from 22 to 24. The epiphyseal cartilage plates of the proximal 5 to 10 bodies now have reached almost their ultimate degree of thinness, suggesting that the initial stage of retarded growth and lapsing has begun.

Forty-fifth Day: The length of the tail is 13.4 to 15.9 cm., and all bodies but the last 2 have secondary centers of epiphyseal ossification. On the tips of the transverse processes of the proximal 2 or 3 bodies are visible new secondary centers of epiphyseal ossification. Distal ventral apophyses are visible in the proximal 8 to 14 segments,

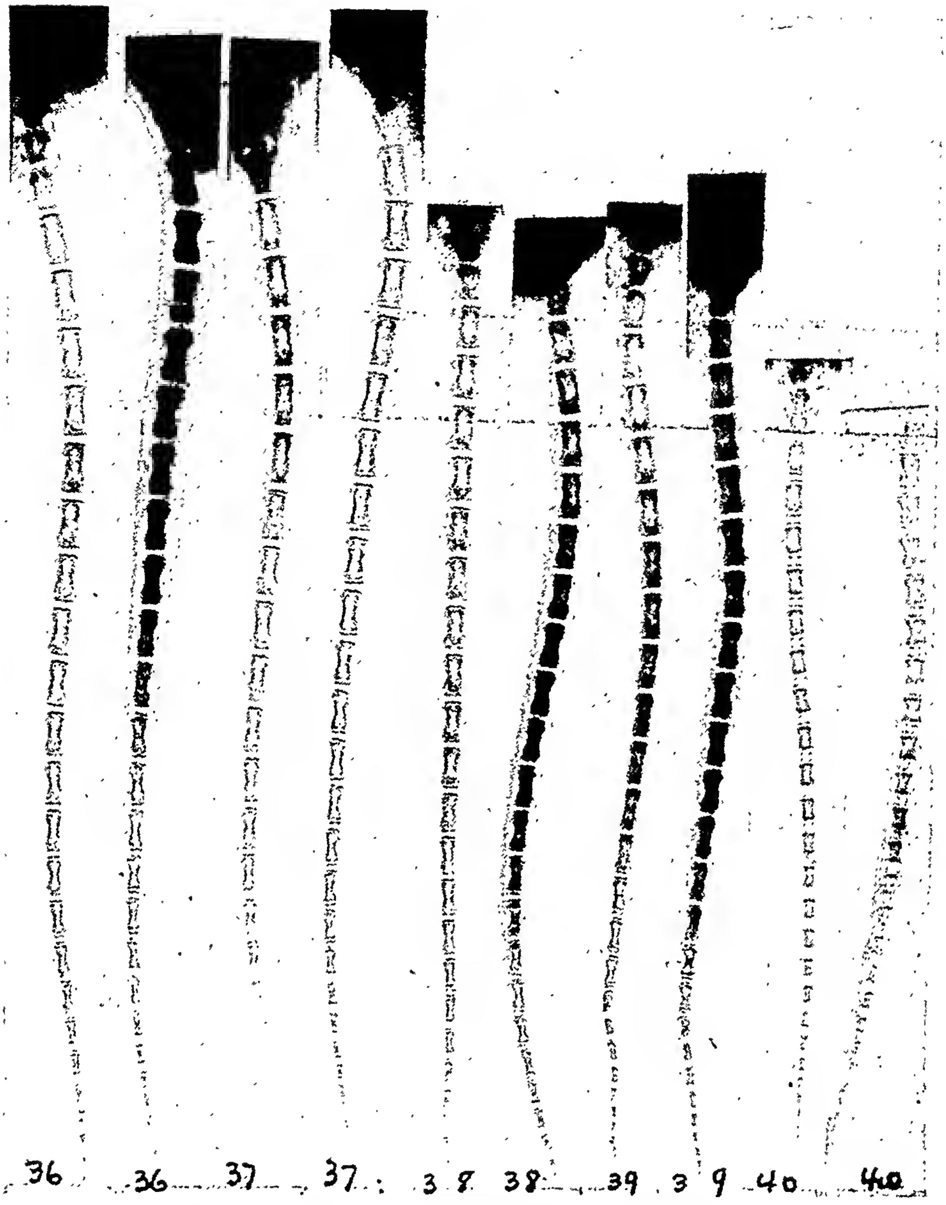

Fig. 6. Rat tail growth between the 36th and 40th day.

having made their first appearance during the preceding one to three days. New centers are also visible at the tips of the spinous processes of the proximal 4 to 10 bodies.

Fiftieth Day: All but the distal 1 or 2 bodies reveal secondary centers of epiphyseal ossification; distal ventral apophyses are present in the proximal 10 to 16 interspaces; and on the proximal 10 to 14 spinous processes and on the transverse processes of 8 proximal bodies, secondary centers of epiphyseal ossification are to be seen.

Sixtieth Day: There are secondary centers of epiphyseal ossification on all bodies except the distal 1 or 2 segments, on the proximal 10 to 14 spinous processes, and on the proximal 6 to 11 transverse processes. The tail length ranges from 15.8 to 17.5 cm. Lapsing seems to have occurred in the epiphyses of the proximal 8 to 10 segments, in which the cartilage plates have reached a degree of thinness characteristic of final growth retardation.

Seventieth Day: There are secondary centers of epiphyseal ossification on the proximal 26 to 28 bodies. Pairs of distal

Fig. 7. Rat tail growth between the 45th and 100th day. During this period, lapsing of bone growth occurs progressively from the proximal to the distal segments.

ventral apophyses number 18 to 20; there are centers at the tips of the transverse processes on 18 to 20 segments and at the tips of the spinous processes of the proximal 16 to 17 segments. The length of the tail varies from 16.5 to 18.5 cm.

Eightieth Day: Secondary centers of epiphyseal ossification are visible at the ends of all the bodies except the last 1 or 2, at the tips of the transverse processes of the first 10 or 12, of the spinous processes of the first 16 or 17, and in the distal ventral apophyses of the proximal 19 or 20 segments. The tail measures 16.5 to 19.2 cm. Lapsing of the main secondary centers of epiphyseal ossification seems to have occurred in the proximal 10 to 16 segments.

Ninetieth Day: The appearances are practically the same as on the 80th day.

One Hundredth Day: There are pairs of distal ventral apophyses of 22 to 24 proximal bodies. The tail length varies from 17.5 to 19.5 cm. Lapsing of the main secondary centers of epiphyseal ossification of all but the distal 5 to 8 segments seems to be present.

From the 100th day to the end of the second year, there are no changes in the number of secondary centers of epiphyseal ossification or in the length of the tail. No actual bony fusion of the epiphyses with the bodies is observed, but the centers seem to become more compact and organized. The cartilage plate between the epiphysis and diaphysis becomes only slightly if at all thinner, except in the terminal 2 to 6 segments, where the cartilage plates remain thicker than those of the more proximal segments, and final lapsing does not seem to occur in them until well along into the second year.

DISCUSSION

The tail measures 1.5 to 2.0 cm. at birth, and during the first three weeks the length increases approximately 2 to 4 mm. daily. In the following weeks, the daily increment in length tends to become less, averaging 1.5 to 3.0 mm. The full length of the tail is reached about the 100th day and varies from 17.5 to 19.5 cm.

The first secondary centers of epiphyseal ossification at either end of the bodies of the proximal 4 or 5 segments appear on or about the 15th day after birth. Each successive day is marked by the appearance of additional centers on one or two succeeding distal segments until, on the 45th day, they appear on all but the terminal one or two segments. The size and shape of these centers change with the growth of the animal. At their first appearance, each center is usually comprised of two isolated nuclei as seen in the anteroposterior view. In the lateral view, these duplicated nuclei are not visible because they are separated by a cleft in the sagittal plane. There may be some irregularity of the nuclear margins in the lateral view, but this is due to lack of uniform calcification. These isolated nuclei of the epiphysis are almost circular when first seen in the anteroposterior view, but with each successive day, they tend to flatten as they extend and approach each other toward the mid-line. On the 7th to the 10th day after their first appearance, they fuse with each other to form a thin disk, slightly convex on the articular side and more or less irregular along the margin bordering the epiphyseal cartilage. For a few days prior to complete fusion, when only a thin bridge of calcification unites the nuclei, these epiphyseal plates have a dumb-bell shape. During the following days, the mid-line defect fills in until the thickness of the epiphyseal disk is almost uniform. After the 25th day, in the anteroposterior view, there appear V-shaped epiphyseal tenons which fit into diaphyseal mortises near the edges of the epiphyseal plates. In the lateral view, a similar pair of tenon-mortise contours may be seen, but not so close to the edges as in the anteroposterior view. About the 80th day, the bony surfaces bounding the cartilage plates begin to get smoother, and on about the 100th day they are quite smooth.

During the succeeding days and weeks, there is no appreciable change in the thickness of the cartilage plates themselves except in the terminal 2 to 6 segments;

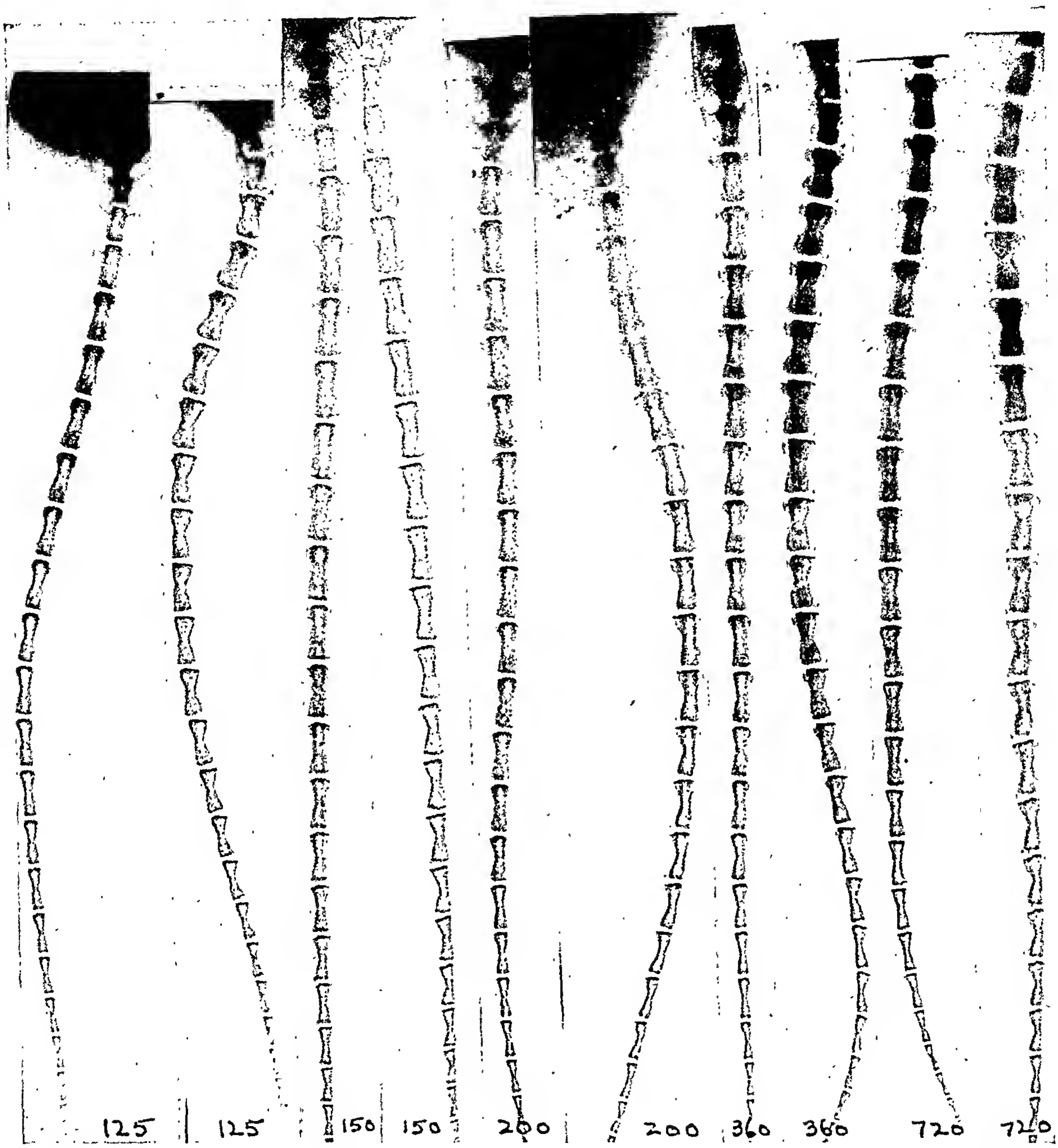

Fig. 8. Rat tail growth from the 125th to the 720th day. There has been lapsed retardation of bone growth during this period, the cartilage plates remaining visible, but thin and discontinuous.

under magnification with a reading hand lens,[3] one can make out thin, compact osteosclerotic bounding zones on either side of these plates. These parallel sclerotic zones bounding the cartilage plate can be seen only in those segments where the central ray of the roentgen beam traverses the zones tangentially. Since the central ray is aimed at the mid-tail, it is only in these segments that the bounding zones of osteosclerosis may be seen. In the adult rat tail, there is slight kyphotic inclination of the articular surfaces of each body, which accounts in part for failure to obtain tangential views of all zones in a single film.

At the tips of the spinous processes, secondary centers of epiphyseal ossification first appear in the proximal 10 to 12

[3] Between 10 and 100 diopters.

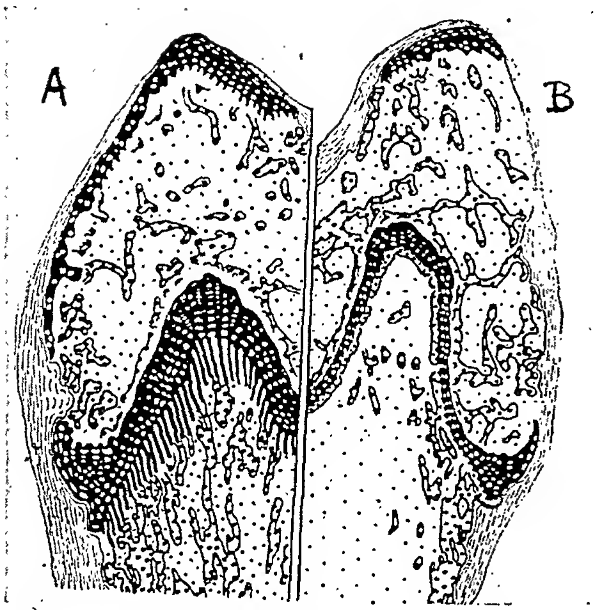

Fig. 9. A. Active bone growth. B. Lapsed bone growth. *After Nunnemacher.*

segments on or about the 45th day after birth. On the 50th day, they have increased in number to include the proximal 13 to 18 segments, where they remain visible during the remainder of the first two years of life.

Pairs of detached apophyses resembling sesamoids appear near the distal ventral articular margins of the first 12 to 15 bodies on or about the 45th day after birth and, gradually, on more distal bodies, so that by the 70th day they are apt to be seen on the proximal 18 to 22, where they remain visible permanently.

At the tips of the transverse processes, secondary nuclei first appear on 2 or 3 proximal divisions on the 46th day; they are visible on the proximal 10 to 12 segments on the 50th day. Around the 250th day, only 7 or 8 may be visible, but even at the end of the first year, 5 to 7 can usually be seen. These nuclei possibly are nothing more than extensions lateralward of the proximal epiphyseal plates, but the connecting bridges are not always visible, thus giving these centers their detached appearance.

Levie (12) found that the body weight, body length, and tail length did not run parallel as growth indices. No attempt was made in our studies to check these conclusions, but we did find that there is considerable normal variation in tail length, probably influenced by such factors as the number of rats in a litter and hereditary, dietary, and seasonal differences. For these reasons, it would seem highly desirable that these factors be reckoned with when undertaking studies of the chondrotropic effects of any test substance.

Strong (19) and Dawson (3) have shown that cartilage plates fall into two pronounced groups: (1) those which become inactive and disappear by the 150th to 180th day, allowing the epiphysis to unite with the shaft; (2) those which become inactive and remain in a lapsed condition until senility. A corresponding state of lapsed cartilage plate activity without actual bony fusion does not occur normally in man except in the lambdoidal and sagittal sutures of the skull (20).

Dodds (4) found that cartilage plates reveal no visible differentiation at birth but, by the 7th day, the cartilage cells become oriented into typical row formation between the diaphysis and epiphysis. By the 14th to the 18th day, the diaphyses and epiphyses are well formed. The cartilage plate then has five zones. Zone I is the layer in the epiphysis just distal to the cartilage plate, where, scattered in the matrix, are reserve cells which divide and give rise to the "mother row cells" in a comparatively thin zone. Zone II, next in line toward the diaphysis, reveals generally the thickest cell multiplication. Here the "mother row cells" undergo two divisions, with short rows of four cells each. These short rows lie end to end to form the long columns characteristic of the cartilage plate. The cells in this zone are normally flat, so that the plane of mitotic division is parallel with the rows. The lengthening of bone is caused by these divisions. Proceeding proximally, in Zone III, the former flat cells become cuboidal. In Zone IV, the cartilage cells become fully developed and then are destroyed by the invading capillaries from the diaphyseal marrow. Calcification also occurs in the matrix between the cell rows. In Zone V, enchondral bone

is laid down as cartilage removal progresses, forming projecting trabeculae. These five zones can be delimited clearly (13).

In the stage of lapsed union, trabeculae on the diaphyseal side of the cartilage plate are absent and there are, instead, smooth layers of lamellate bone on both sides of the cartilage plate which are quite thin. In this same phase of lapsed activity, the cartilage rows become short and sparse, with large patches of dense fibrillar matrix between them. Silberberg and Silberberg (16) noted that the cartilage plate gets progressively narrower in the upper tibia from about the 55th day. They found that by the end of four or five months it was only half its original width, and that, by the eighth or ninth month, only a thin sclerotic line of euhyaline cartilage could be seen delimited toward both the epiphysis and diaphysis by a layer of bony tissue. Even in the third year of life, they found rudimentary cartilage and calcium deposits in the epiphyseal plate, which was by that time transformed into a thin, sometimes discontinuous, transverse plate containing scanty remnants of cartilage. Thus, no evidence of actual bony epiphysio-diaphyseal union was found to have occurred. It was also found in the mouse that active growth proceeded for about 120 days, when proliferative activity ceased and retrogressive processes set in, characterized by atrophy, degeneration, and calcification of the epiphyseal cartilage.

Silberberg and Silberberg quote similar observations by Dawson in the rat and they make the pertinent observation that at no time did they note vascular perforations of the epiphyseal cartilage, as in man or dog, where at the initiation of ossification in the epiphysis, osteogenic invasions from the diaphysis are readily observed. In old rats, Dawson (2) found that the final obliteration of the cartilage, when it does occur, appears to be the result of transformation of the residual cartilage by metaplasia rather than by destruction, succeeded by bony substitution. In man, Dawson further pointed out, growth in the length of a bone, due to the activity of the epiphyseal cartilage plate, may cease long before the cartilage plate itself is obliterated and, for some reason not clearly understood, the final differentiation of this zone is delayed. In the rat, in those areas, as the olecranon, femoral head, distal femur, proximal tibia, distal radius, humeral head, scapula, pelvic margins, and tail, where the cartilage of conjugation persists throughout life, Dawson found it impossible, due to the extreme variability of the histologic pattern, to determine any definite age at which it could be said with certainty that growth had ceased and union or differentiation had become retarded.

Levie (12), on the other hand, claimed that in the rat, the proximal 12 secondary centers of epiphyseal ossification in the tail fused on the 55th day and that from the 70th to the 119th day progressive fusion of the distal segments occurred. Our findings substantiate these observations. It was evident to us that lapsing of the tail epiphyses begins in the proximal segments about the 45th day and progressively involves more segments daily thereafter until the 100th day, when lapsing of all but the last 2 or 3 segments has occurred. Much of each cartilage plate between the diaphysis and epiphysis can be seen in the roentgenograms for the remainder of the rat's life, even though these plates may be thin, discontinuous, and of varying densities.

Faulty sectioning and staining may lead to unwarranted conclusions about the persistence and disappearance of the cartilage plate. Silberberg and Silberberg (16) pointed this out in the mouse, in which the first stage of epiphyseal proliferation is followed after 120 days by the second stage, characterized by atrophy, degeneration, and calcification of the epiphyseal cartilage; the localized degenerated areas in the epiphyseal zone, originating by coalescence of several degenerated cartilage cell rows, are then the areas which may lead to trouble in diagnosis. The Silbergs pointed out that Schmorl (15) called these areas "Ossifikationslücken,"

assuming that no calcification could take place in them; that Erdheim (5) considered these areas foci of calcification to brace the excessive amount of soft cartilage formed in acromegaly, and that Böhmig (1) defined them as sites of degeneration which later underwent ossification as a result of a disturbance in growth. The Silberbergs considered all these changes normal, as part of the process of epiphyseal lapsing, so that it seems warranted to say that the *sine qua non* in the appraisal of chondrotropic effects is a thorough knowledge of these normal but variable microscopic appearances.

Other important observations made by the Silberbergs in the mouse which are applicable to the rat, as shown by Hammett (11), Spark and Dawson (17), are that the female reveals the epiphyseal proliferative process of the first stage of cartilage growth two or three weeks in advance of the male, and that the male is earlier than the female in revealing the characteristic changes of the third stage of lapsing. They also pointed out a strain difference in the time schedule of the stages of proliferation and lapsing of the growth centers, and they were inclined to attach significance to these findings in so far as signs of more rapid aging of the growth centers occurred in mice strains with a natural high incidence of mammary cancer, possibly due to excessive estrogens. These fine histologic variations probably cannot be demonstrated in roentgenograms and these important limitations of roentgenography must be considered in planning methods for studying chondrotropic effects. On the other hand, Dawson (2) found an inconstant variation of retardation of bony epiphyseal fusion in many individual rats, so that it is obvious, in studying chondrotropic effects, that large numbers of animals must be observed; this could be accomplished more readily by roentgen than by histologic methods.

For the bioassay of pituitary growth hormones, Evans, Simpson, Marx, and Kibrick (7) used 26-day-old female rats, which they injected with the hormone of unknown potency for four days beginning on the 12th day after hypophysectomy. By a rapid staining method, they could measure the thickness of the proliferating cartilage plate under a microscope with a calibrated micrometer eye-piece. By comparing with controls, they worked out criteria for bioassay of the pituitary hormones. It would be interesting to compare their method with roentgen procedures such as are suggested in this report, employing a fixed scale of magnification with a low diopter lens.

SUMMARY

1. X-ray growth zone studies were made of a large number of tails of Wistar rats from birth until two years of age.

2. A description is given of the daily variations of the bodies and secondary centers of epiphyseal ossification as seen in the roentgenograms.

3. The histologic pictures of the growth zones in normal rats and mice are reviewed and compared with the roentgen characteristics.

4. A growth calendar is suggested, which could be used to study chondrotropic effects.

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Depth and Exit Doses for Various Phantom Thicknesses[1]

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WHEN APPLYING depth dose values for treatment purposes, the thickness of the phantom used in determining the dose at depth is frequently ignored. That this factor influences the dose at depth to a significant degree has been shown by Stenström and Reinhard (1), who stated that when the thickness of the patient was less than that of the phantom used to establish the depth dose values, the dose at the point of radiation exit was 25 per cent less than the chart values, and that the dose inside

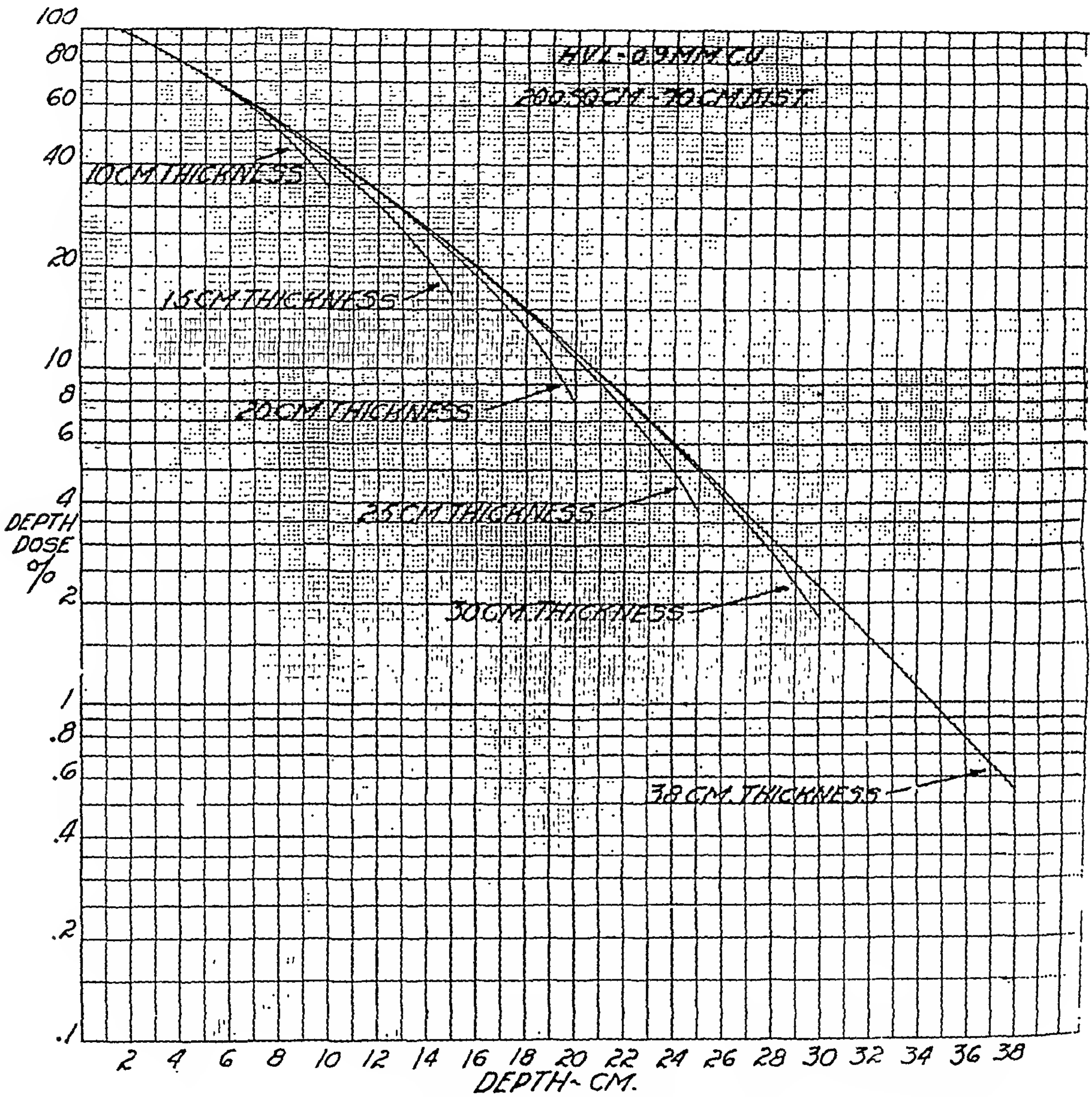

Fig. 1. Depth dose curves for various phantom thicknesses for one quality and one field size only.

[1] From the State Institute for the Study of Malignant Diseases, Buffalo, New York, Dr. William H. Wehr, Acting Director. Accepted for publication in October 1944.

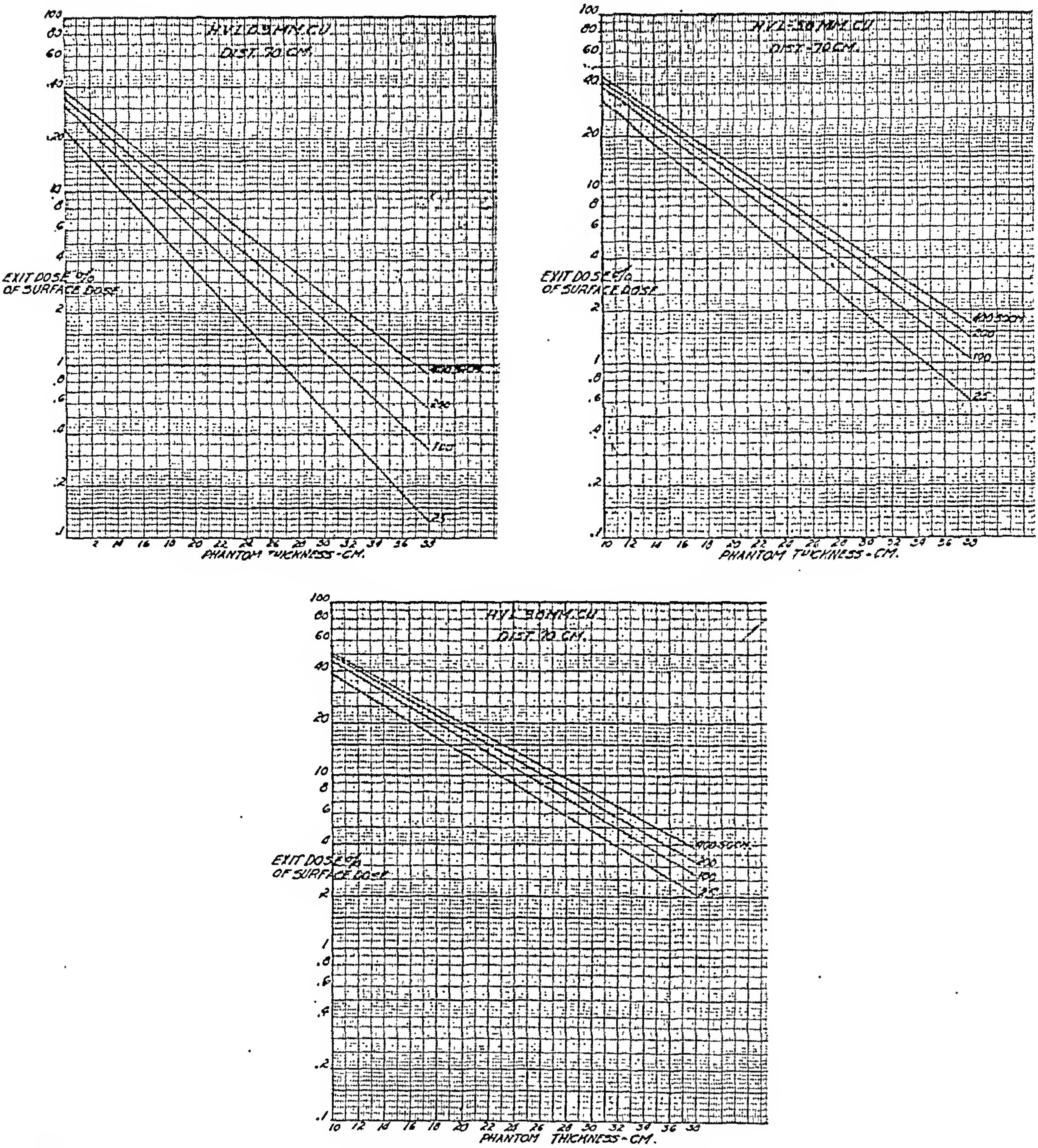

Fig. 2. Curves presenting exit doses for phantom thicknesses ranging from 10 to 38 cm., for three qualities, 0.9, 5.0, 9.0 mm. Cu h.v.l., and for four field sizes.

the tissues near the point of exit would also be somewhat smaller than the chart values. Quimby (2), in her Syllabus of Lectures, also points out that the full phantom depth values at 200 kv. may not be used directly as exit values where the diameter of the irradiated part is smaller than the full phantom thickness. The full phantom values must be reduced by a factor depending on the area treated and on the thickness of the part to be irradiated. The exit doses thus obtained range from 72 to 90 per cent of the full phantom depth values. Aebersold and Chaffee (3) have compared exit doses for 200 kv. with those for 1,000 kv., using four phantom thicknesses. Comparing a 12-cm. phantom with a 24-cm. phantom, they show that the decrease in depth dose associated with the smaller amount of back-scatter of the

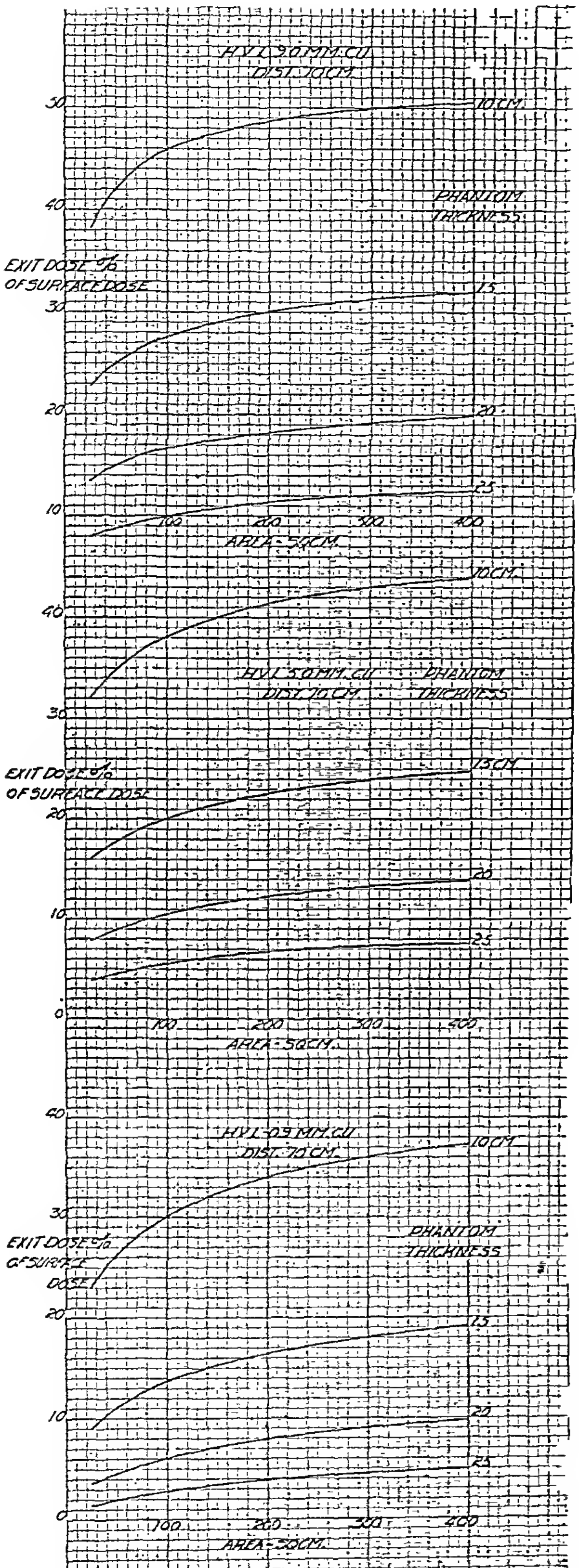

Fig. 3. Curves showing exit doses for field sizes ranging from 25 to 400 sq. cm. for three qualities of radiation and for phantom thicknesses of 10, 15, 20, and 25 cm.

thinner phantom, is apparent approx mately 10 cm. above the exit surface.

In order to investigate the relationsh between depth dose and exit dose for 2(kv. (0.9 mm. Cu h.v.l.), 400 kv. (5.0 mı Cu h.v.l.), and 1,000 kv. (9.0 mm. (h.v.l.) with field sizes of 25, 100, 200, aı 400 sq. cm., measurements were made wi a thimble type ionization chamber at 5 70, and 90 cm. distance. A presdwo phantom[2] was used, whose maximum thic ness was 38 cm. This phantom could divided into sections 10, 15, 20, 25, and cm. thick. The exit surface intensiti were determined by one-half submergen of the ionization chamber in a recess in t exit surface of the phantom. In order simulate conditions which would ex under actual therapy procedure, the pha toms were always resting on a sponge-ru ber mattress. The radiation beam w limited by the opening in the tube head a by lead sheets placed directly on the su face of the phantom. These sheets ov lapped the surface and had square ho cut in them to give the desired area The thicknesses of the lead sheets used f the various voltages were as follows: 1 in. for 200 kv., 1/2 in. for 400 kv., and in. for 1,000 kv., in addition to the regu collimating devices.

TABLE I

Phantom Thickness	Reduction
10 cm.	20%
15 cm.	28%
20 cm.	29%
25 cm.	25%
30 cm.	16%

Based on these measurements, famil of depth dose curves were drawn for fi phantom thicknesses for all quality, ar and distance combinations indicated. typical family of such curves for one fi size and one distance is shown in Figure In this curve the D_5, D_{10}, and D_{15} valu for the 38-cm. phantom are the same those published earlier (4). These curv show that, due to the lack of back-scatt

[2] This is the same phantom which was used for measurements published in Radiology 40: 283-2 March 1943, where, through a typographical error, thickness was given as 28 cm.

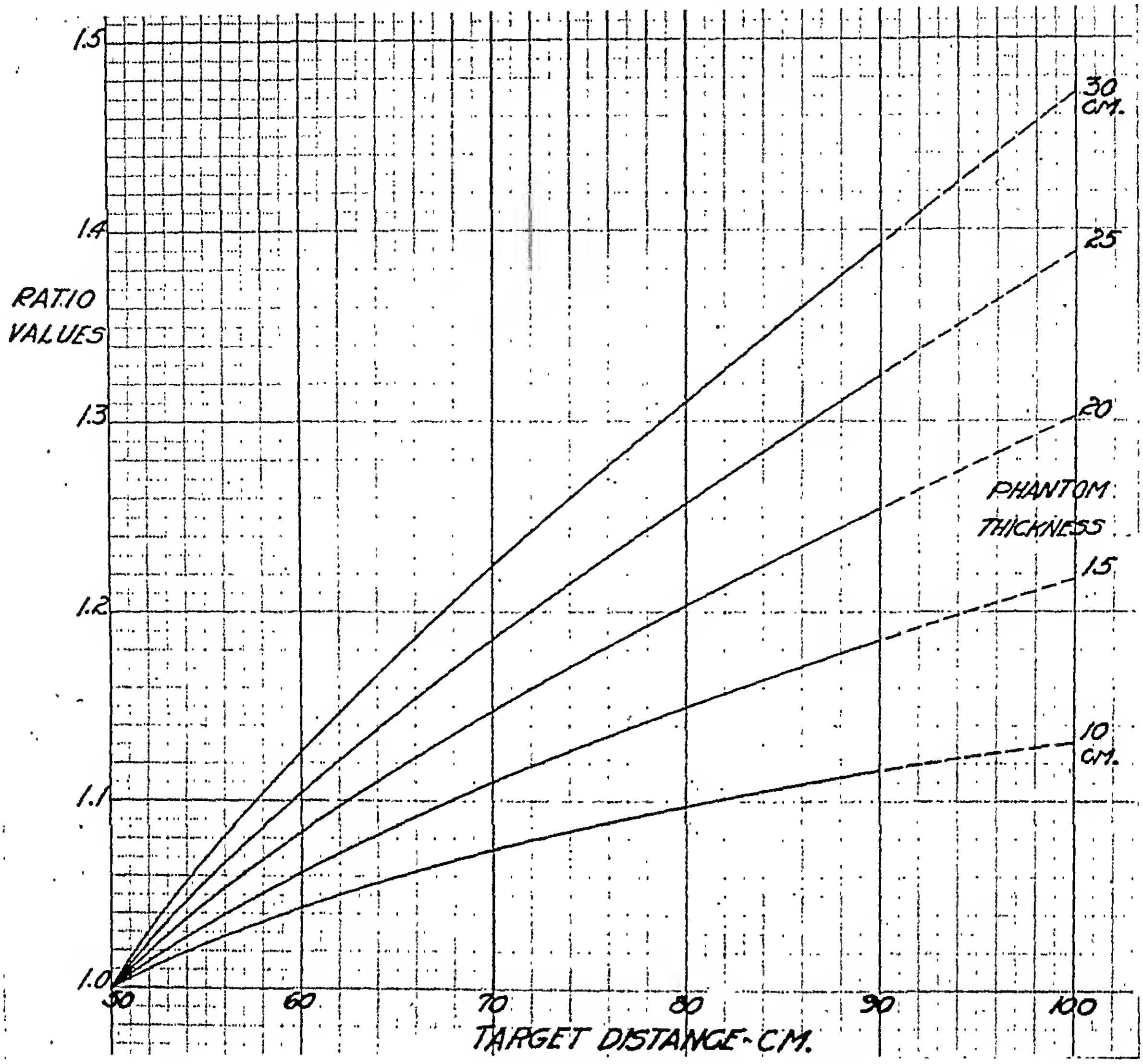

Fig. 4. Distance ratio curves for depth doses at 10, 15, 20, 25, and 30 cm. or exit doses for 10, 15, 20, 25, and 30 cm. phantom thicknesses.

the depth values for any phantom thickness *less than the full phantom* depart from those of the latter at a point 8 to 10 cm. preceding the exit surface. A calculation of the percentage reduction from the full phantom depth values for the various phantom thicknesses is shown in Table I for this particular quality and area only.

The percentage deviation becomes progressively greater with increasing phantom thickness, until the thickness approaches that of the full phantom, when the percentage becomes smaller. However, as pointed out by Quimby (2), the depth dose values for the thicker phantoms are so small that any correction would yield insignificant results. In the previous table, for example, the percentage correction for the 25-cm. phantom is 25 per cent. This would appear to be a large variation, but the depth value for the full phantom at 25 cm. depth is actually only 5.1 per cent, and 25 per cent of 5.1 is insignificant for practical purposes.

It will be noticed, from the family of curves, that a straight line could be drawn through the exit dose values for all of the thicknesses shown in Figure 1. Since the publication of such families of depth curves for all qualities, fields, and distances would occupy too much space, it was decided to limit the published data to the curves

showing only exit values at 70 cm. distance. Figure 2 shows the straight line plot of the exit values for the three qualities and the four areas at 70 cm. distance, when the exit values expressed in terms of per cent of surface dose are plotted on semilog paper against phantom thickness. A plot of the previously published D_5, D_{10}, and D_{15} values, together with the exit dose values for the various phantom thicknesses, would permit complete depth curves to be drawn in a manner similar to Figure 1.

A replot of the data of Figure 2, with exit dose plotted against area, is presented in Figure 3. From these curves it is possible to obtain the exit dose for intermediate areas.

Up to this point we have discussed the exit depth dose relationship for three qualities at 70 cm. distance. By comparing these values with those measured values at 50 and 90 cm. distance, it was found that the exit dose-distance relationship could be expressed in the form of simple ratios for the five phantom thicknesses. These ratios may be applied to all qualities and areas, provided area and quality are constant when transposing from one distance to another. From this series of measurements it was found that these distance ratios, shown in Figure 4, not only apply to exit values but may also be used to calculate depth dose values at 10, 15, 20, 25, and 30 cm. depth.

SUMMARY

A series of curves is presented showing the exit doses for three qualities of radiation, 9.0, 5.0, and 0.9 mm. copper h.v.l., for phantom thicknesses varying from 10 to 38 cm. at 70 cm. distance. Ratio curves are also presented which permit the calculation of exit doses or depth doses for distances from 50 to 90 cm. These exit dose calculations, used in conjunction with previously published depth values, make it possible to derive complete depth dose curves within the limits of field size, distance, and qualities indicated.

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EDITORIAL

Neuroblastoma Sympatheticum

Sympathetic neuroblastoma, with its frequent accompaniment of widespread metastases, has been generally accorded an unfavorable prognosis. From a study of the many accumulated reports, it becomes evident that these tumors are moderately radiosensitive. If they are attacked by radiation therapy or by complete surgical extirpation while still localized at the point of origin, or even after extension to the liver, there is a reasonable chance of permanent cure.

These neoplasms, as their name implies, are classified with the neurogenic tumors, as they originate from the tissue of the sympathetic nervous system in the adrenal medulla or elsewhere. Pepper originally described them as "sarcomas" arising in the adrenals and metastasizing to the liver. Hutchinson later reported primary adrenal tumors with widespread metastases, especially in the skull and bones of the face. It has since been shown that, though they have a special predilection for the skeletal system, metastases may occur in almost any organ of the body and the two types described above are merely different manifestations of the same condition distinguished by the spread of the disease. The areas of spread, however, have a definite implication for the ultimate prognosis, as will be shown later.

Adrenal neuroblastomas are encountered most commonly in children under four years of age but may occur in adults. The initial symptom may be pain referred to the spine and legs, but in most cases an abdominal mass is the primary complaint. Other symptoms depend upon extension of the neoplasm or metastases. One characteristic of the tumor is its tendency to cross the mid-line. Proptosis of one or both eyes with discoloration of the lids may occur in the presence of retro-orbital metastases.

Roentgenograms of the abdomen are not characteristic. With metastases in the long bones, the picture is varied. The most common areas of involvement are in the ends of the diaphyses adjacent to the epiphyseal lines and on the medial border. In advanced cases these changes may extend the full length of the shaft. The resorption may be of uneven density, suggesting a diffuse infiltration rather than massive destruction. There may be osteoporosis of extreme grade before actual destruction takes place. In the skull there is evidence of increased intracranial pressure and a finely granular type of osteoporosis, indicating minute foci of bone resorption. Other flat bones show a similar type of infiltration. The tumor is usually encapsulated and as a rule compresses the kidney rather than invades it. Metastasis to the retroperitoneal lymph nodes is more common than to the bones or liver.

The tumors are quite cellular, with scanty stroma. The cells are small, with hyperchromatic nuclei and a narrow rim of cytoplasm. Rosette formation—a circular arrangement of cells—about bundles of fibrillae is regarded as characteristic of the histologic picture.

For the therapeutic approach, the first consideration is the certainty of a correct diagnosis. In the presence of an abdominal tumor suspected of being a neuroblastoma and with no clinical or roentgen evidence of metastases, an exploratory operation should be undertaken. Complete removal of the tumor should be done if it is free and can be removed without cutting across it. Since the tumors have been shown by a number of observers to be radiosensitive,

postoperative radiotherapy should be given without delay in all cases without known metastases. In those cases with regional extension and peripheral metastases radiotherapy will be found to be of palliative value.

Ladd and Gross (3) report 7 probable cures of abdominal neuroblastoma from a series of 32 histologically verified cases. One patient had been well eight and one-half years with no treatment except biopsy. Three were well seven and one-half, six, and five and one-half years, respectively, following surgical removal without irradiation. *Another, with a retroperitoneal* growth extending into the spinal canal, was treated by incomplete surgical removal followed by x-ray therapy and was well four years later. Two patients with metastases in the liver received x-ray therapy following operation and biopsy and were in good health after intervals of three and one-half and two years. In view of the rapid course of untreated cases, Ladd and Gross believe that one may speak of a permanent cure if the patient remains well a year after surgical or roentgen therapy. Lehman (4) in 1932 reported a case of surgical removal of a tumor from an infant fifteen years previously. The patient was living and well at the time of the report.

Wyatt and Farber (5), in an extensive review of the subject, include 2 cases with extensive metastases to the liver. Treatment was by x-ray irradiation, and the children were alive and well three and two years later. None of the patients with widespread metastases was cured, although considerable improvement was observed in two. Hauser reported a single case in which metastases in the lungs and cervical lymph nodes disappeared following irradiation. Later, however, generalized metastases led to a fatal termination. In another series (1) of three patients treated by radiation, regression of the local growth was observed in two, but owing to extensive metastases the relief was only temporary. The tumors were moderately radiosensitive.

From the reports cited above it is apparent that, though the prognosis in these *cases is without question unfavorable*, complete resection or adequate x-ray therapy while the tumor is still localized to the adrenal offers a reasonable chance of complete cure. If the disease has spread to the regional nodes or even metastasized to the liver, there is still a possibility of a favorable outcome, but no report could be found of a cure by any method of treatment after distant metastases had developed.

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AMERICAN BOARD OF RADIOLOGY EXAMINATION

The examination of the American Board of Radiology originally scheduled for June in New York was canceled. The next examination will be in Chicago in the fall. Due notice will be sent out as soon as the time and place have been determined.

NEW ENGLAND ROENTGEN RAY SOCIETY

At its meeting on May 18, 1945, the New England Roentgen Ray Society paid honor to its distinguished member, Dr. George W. Holmes, pioneer radiologist and teacher, by establishing an annual lecture to be known as the George W. Holmes Annual Lecture.

The newly elected officers of the Society are Dr. Philip Batchelder, Providence, R. I., President; Dr. Robert G. Vance, Boston, Vice-President; and Dr. George Levene, Boston, Secretary.

PITTSBURGH ROENTGEN SOCIETY

At a recent meeting of the Pittsburgh Roentgen Society the following officers were elected for the ensuing year: President, Dr. Reuben G. Alley; Vice-President, Dr. Paul Meader; Secretary-Treasurer, Dr. Lester M. J. Freedman.

RADIOLOGICAL SOCIETY OF NEW JERSEY

At the annual meeting of the Radiological Society of New Jersey held on May 16, 1945, the following members were elected to office: President, Dr. H. J. Perlberg, Jersey City; Vice-President, Dr. John Olpp, Englewood; Secretary, Dr. H. R. Brindle, Asbury Park; Treasurer, Dr. W. H. Seward, Orange; Councilor to the American College of Radiology, Dr. J. H. Wyatt, Newark.

DR. CHARLES M. HAMILTON HONORED

Dr. Charles Marshall Hamilton of Nashville, Tenn., a member of the Radiological Society of North America for nearly twenty-five years, was recently chosen president-elect of the Tennessee State Medical Association.

Book Reviews

Clinical Roentgenology of the Digestive Tract. By Maurice Feldman, M.D., Assistant Professor of Gastroenterology, University of Maryland; Assistant in Gastroenterology, Mercy Hospital, Baltimore; Consulting Roentgenologist, Sinai Hospital, Baltimore. A volume of 769 pages. Published by The Williams and Wilkins Co., Baltimore. Second Edition, 1945. Price $7.00.

Feldman's "Clinical Roentgenology of the Digestive Tract" was originally published in 1938. This new edition, the second, brings the subject matter satisfyingly up to date. Much of the text has been rewritten and nearly 200 illustrations have been added.

Starting with the esophagus in the first chapter, the author proceeds to discuss the remainder of the digestive tract in orderly, concise, readable, and understandable fashion. All phases of gastro-intestinal roentgenology are adequately, though in some instances briefly, covered. Various diseases and conditions are discussed in clear, direct terms without redundancy, and there are many good suggestions on technic. The bibliography is adequate and, being given immediately following each subject touched upon in a chapter, is easy to find and consult. Special chapters are devoted to the gall-bladder, the pancreas, peritoneum, omentum, the mesentery and retroperitoneal tumors, lymphomatous diseases, the abdominal vessels, the spleen, and deficiency diseases.

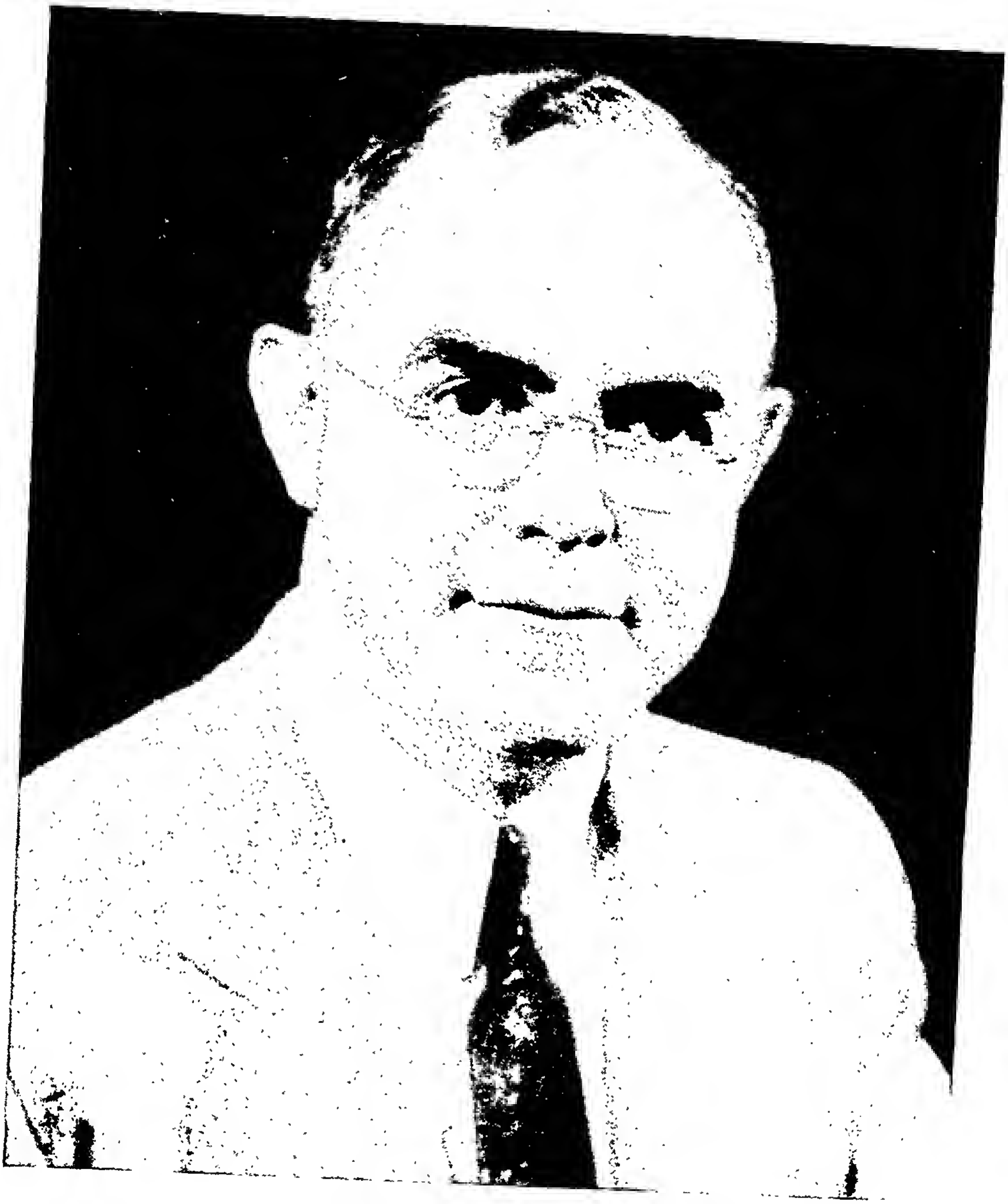
The print is easy to read, and the numerous roentgenographic reproductions are of good quality. More illustrations showing gross pathology, would, however, be a useful addition.

The student, the gastroenterologist, and the roentgenologist will find this volume a valuable and ready source of accurate information and a helpful reference work in the study and solution of the multiple and difficult problems encountered in coping with gastro-intestinal tract disease and dysfunction.

What Are Cosmic Rays? Revised and Enlarged American Edition. By Pierre Augur, Professor at the Ecole Supérieure Normale, France, Research Associate in Physics, University of Chicago, Fellow of the American Physical Society. Translated from the French by Maurice M. Shapiro. A volume of 128 pages, with numerous photographs. Published by The University of Chicago Press, Chicago. Price $2.00.

The author of "What Are Cosmic Rays?" is an old friend of the radiologists, having worked out and published many of the fundamental discoveries upon which the science of radiology is based. In this book he has done a superb job of writing about cosmic ray research in simple language, directly and accurately—language that any layman can understand, yet free of far-fetched metaphores and misleading analogies. The book is not in any way similar to the manifold "popular science" outbursts so common on the market. The argument is a clever interweaving of history and technic, which works out in a most entertaining manner.

Since a critic must criticize something, it might



RALPH EMERSON MYERS
1888-1945

be said that the author should have done a better job of showing the practical value of his work. Cosmic ray research has made it possible to understand and apply the power that has come to us through the newer developments of high-voltage generators and radioactive substances. The author begins by telling about the early discoveries and, at the same time, the instruments that made these discoveries possible, giving a completely interwoven account of events as they actually happened. People who have had no occasion to work with a Geiger counter or study the complexities of a cloud chamber may obtain a painless understanding of these things in the first ten pages, enough so that they can enjoy the rest of the story as it unfolds.

The second chapter deals with cosmic ray exploration. It avoids all the pitfalls which might have made it a boring tale of adventure and explains why and how the cosmic-ray map of the world was plotted and intensity measurements were made in the stratosphere and the depth of the ocean. From there on the book deals with the energetic particles that are components of the cosmic ray, their nature and behavior, and what is known of their significance. The reader is offered a first-class literary acquaintance with the mesotron and its relatives. In the end he is brought up to date, as nearly as possible, and given food for thought as to future developments.

MASS RADIOGRAPHY OF THE CHEST. By HERMAN E. HILLEBOE, M.D., Medical Director, Chief, Tuberculosis Control Division, U. S. Public Health Service; Professorial Lecturer on Tuberculosis Control, George Washington University School of Medicine, Washington, D. C., and RUSSELL H. MORGAN, M.D., Surgeon (R), Medical Officer-in-Charge, Radiology Section, Tuberculosis Control Division, U. S. Public Health Service; Assistant Professor of Roentgenology (absent on leave), The University of Chicago. A volume of 288 pages, with 93 illustrations. Published by the Year Book Publishers, Inc., Chicago, Ill. Price $3.50.

This small manual is a much needed volume giving a well rounded picture of mass radiography of the chest. Every phase of the subject is covered with clarity and in sufficient detail for practical purposes. The authors set forth the methods of applying the procedure to industrial surveys, surveys of the civilian population, and to general hospital work, discussing such projects from the standpoint of space requirements, personnel, apparatus, and the rapid handling of patients.

The description of the various types of available equipment is valuable and informative. The chapter on physical factors affecting the choice of equipment includes much new material on x-ray physics, especially as applied to photofluorography. The roentgen technic is described and special emphasis is placed on protection of the operator.

The chapter on roentgen diagnosis is concise and presents clearly the important changes that may be discovered in a study of miniature films. It is illustrated with 48 full-page photofluorograms.

The book is attractively printed and illustrated and is especially timely now that new equipment for mass surveys may soon become available. It should be in the possession of every roentgenologist, as well as those interested in tuberculosis and industrial medicine.

In Memoriam

RALPH EMERSON MYERS, M.D.

1888–1945

Dr. Ralph Emerson Myers of Oklahoma City, Counselor of the Radiological Society of North America for his state, died after a brief illness on March 14, 1945. Dr. Myers was born in Buskirk, New York, in 1888. He was graduated from Yale University in 1909 and received his master's degree the following year. He was chief chemist at the Battle Creek Sanitarium in 1910–11, held the Austin teaching fellowship in physiology at the Harvard Medical School in 1911–12, and was successively lecturer (1912–13) and adjunct professor (1913–14) of pharmacology and physiology in Albany Medical College (Union University). He received his M.D. from Cornell Medical College in 1918 and served his internship in Memorial Hospital, New York. After a year's service in the Army, he returned to teaching, first as professor of pharmacology in the University of Maryland School of Medicine (1919–20) and then of pharmacology and physiological chemistry in the George Washington University School of Medicine (1920–22). He was director of laboratories in St. Anthony's Hospital, Oklahoma City, from 1920 to 1929, after which date he devoted himself to practice in that city.

Dr. Myers was a fellow of the American Medical Association and of the American College of Radiology. He was a diplomate of the American Board of Radiology and a member of the American Radium Society and of the Radiological Society of North America, as well as of the American Society of Clinical Pathologists, the American Society for the Study of Neoplastic Diseases, the American Association for the Advancement of Science, and the Southern Medical Association.

WILLIAM MARSHALL BARRON

1890–1945

Dr. Wm. Marshall Barron of Ackerman, Miss., died on Jan. 18, 1945. Doctor Barron received his medical degree from Tulane University in 1914 and practised in San Antonio, Texas, where he was roentgenologist to the Robert B. Green Memorial Hospital. He was a member of the Radiological Society of North America.

Editor's Note.—Will secretaries of societies please cooperate by sending information to Howard P. Doub, M.D., Editor, Henry Ford Hospital, Detroit 2, Mich.

UNITED STATES

Radiological Society of North America.—Secretary, D. S. Childs, M.D., 607 Medical Arts Bldg., Syracuse 2, N.Y.

American Roentgen Ray Society.—Secretary, Harold Dabney Kerr, M.D., Iowa City, Iowa.

American College of Radiology.—Secretary, Mac F. Cahal, 20 N. Wacker Dr., Chicago 6, Ill.

Section on Radiology, American Medical Association.—Secretary, U. V. Portmann, M.D., Cleveland Clinic, Cleveland 6, Ohio.

ARKANSAS

Arkansas Radiological Society.—Secretary, J. S. Wilson, M.D., Monticello. Meets every three months and annually at meeting of State Medical Society.

CALIFORNIA

California Medical Association, Section on Radiology.—Secretary, Gordon King, M.D., Children's Hospital, San Francisco.

Los Angeles County Medical Association, Radiological Section.—Secretary, Roy W. Johnson, M.D., 1407 South Hope St., Los Angeles. Meets second Wednesday of each month at County Society Building.

Pacific Roentgen Society.—Acting Secretary, Frederick H. Rodenbaugh, M.D., 490 Post St., San Francisco. Meets annually with California Medical Association.

San Diego Roentgen Society.—Secretary, Henry L. Jaffe, M.D., U. S. Naval Hospital, San Diego, Calif. Meets first Wednesday of each month.

San Francisco Radiological Society.—Secretary, Carlton L. Ould, University Hospital, Medical Center, San Francisco 22. Meets monthly on the third Thursday at 7:45 P.M., first six months of the year in Lane Hall, Stanford University Hospital, and second six months in Toland Hall, University of California Hospital.

COLORADO

Denver Radiological Club.—Secretary, A. Page Jackson, Jr., M.D., 304 Republic Bldg., Denver 2. Meetings third Friday of each month, Denver Athletic Club.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Secretary, Max Climan, M.D., 242 Trumbull St., Hartford 3. Meetings bimonthly, second Thursday.

FLORIDA

Florida Radiological Society.—Secretary-Treasurer, J. F. Pittman, M.D., Blanche Hotel Annex, Lake City.

GEORGIA

Georgia Radiological Society.—Secretary-Treasurer, James J. Clark, M.D., 478 Peachtree St., N. E., Atlanta 3. Meets in November and at the annual meeting of State Medical Association.

ILLINOIS

Chicago Roentgen Society.—Secretary, Fay H. Squire, M.D., 1753 W. Congress St., Chicago 12. Meets at the Palmer House, second Thursday of October, November, January, February, March, and April.

Illinois Radiological Society.—Secretary-Treasurer, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—Secretary, Frank S. Hussey, M.D., 250 East Superior St., Chicago 11.

INDIANA

The Indiana Roentgen Society.—Secretary-Treasurer, Harold C. Ochsner, M.D., Methodist Hospital, Indianapolis 7. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Secretary, Arthur W. Erskine, M.D., Suite 326 Higley Building, Iowa City. Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—Secretary-Treasurer, Sydney E. Johnson, 101 W. Chestnut St., Louisville.

LOUISIANA

Louisiana Radiological Society.—Secretary-Treasurer, Johnson R. Anderson, M.D., North Louisiana Sanitarium, Shreveport. Meets annually at same time as State Medical Society.

Shreveport Radiological Club.—Secretary, Oscar O Jones, M.D., 2622 Greenwood Road. Meets monthly September to May, third Wednesday, 7:30 P.M.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Secretary, Charles N. Davidson, M.D., 101 West Read St., Baltimore 1.

MICHIGAN

Detroit X-ray and Radium Society.—Secretary-Treasurer, E. R. Witwer, M.D., Harper Hospital, Detroit 1. Meetings first Thursday of each month from October to May, at Wayne County Medical Society club rooms.

Michigan Association of Roentgenologists.—Secretary, Bruce MacDuff, M.D., 201 Sherman Bldg., Flint 3.

MINNESOTA

Minnesota Radiological Society.—Secretary, A. T. Stenstrom, M.D., Minneapolis General Hospital, Minneapolis 26. Meetings quarterly.

MISSOURI

Radiological Society of Greater Kansas City.—Secretary, John W. Walker, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Friday of each month.

St. Louis Society of Radiologists.—Secretary, Edwin C. Ernst, M.D., 100 Beaumont Medical Bldg. Meets on fourth Wednesday of each month except June, July, August, and September.

NEBRASKA

Nebraska Radiological Society.—Secretary-Treasurer, Donald H. Breit, M.D., University of Nebraska Hospital, Omaha 5. Meetings third Wednesday of each month at 6 P.M. in either Omaha or Lincoln.

NEW ENGLAND

New England Roentgen Ray Society.—Secretary-Treasurer, George Levene, M.D., Massachusetts Memorial Hos-

pitals, Boston, Mass. Meets monthly on third Friday at Boston Medical Library.

NEW HAMPSHIRE

New Hampshire Roentgen Society.—Secretary-Treasurer, Richard C. Batt, M.D., St. Louis Hospital, Berlin.

NEW JERSEY

Radiological Society of New Jersey.—Secretary, H. R Brindle, M.D., 501 Grand Ave., Asbury Park. Meetings at Atlantic City at time of State Medical Society and midwinter in Newark as called.

NEW YORK

Associated Radiologists of New York, Inc.—Secretary, William J. Francis, M.D., East Rockaway, L. I.

Brooklyn Roentgen Ray Society.—Secretary-Treasurer, Leo A. Harrington, M.D., 880 Ocean Ave., Brooklyn 26. Meets fourth Tuesday of every month, October to April.

Buffalo Radiological Society.—Secretary-Treasurer, Joseph S. Gian Franceschi, M.D., 610 Niagara St., Buffalo 1. Meetings second Monday evening each month, October to May, inclusive.

Central New York Roentgen Society.—Secretary-Treasurer, Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse 10. Meetings in January, May, and October.

Long Island Radiological Society.—Secretary, Marcus Wiener, M.D., 1430 48th St., Brooklyn 19. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—Secretary, Wm. Snow, M.D., 941 Park Ave., New York 28.

Rochester Roentgen-Ray Society.—Secretary, Murray P. George, M.D., 260 Crittenden Blvd., Rochester 7. Meets at Strong Memorial Hospital, third Monday, September through May.

NORTH CAROLINA

Radiological Society of North Carolina.—Secretary-Treasurer, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meets in May, and October.

NORTH DAKOTA

North Dakota Radiological Society.—Secretary, Charles Heilman, M.D., 1338 Second St., N., Fargo.

OHIO

Ohio Radiological Society.—Secretary, Henry Snow, M.D., 1061 Reibold Bldg., Dayton 2. Next meeting at annual meeting of the Ohio State Medical Association.

Cleveland Radiological Society.—Secretary-Treasurer, Don D. Brannan, M.D., 11311 Shaker Blvd., Cleveland 4. Meetings at 6:30 P.M. on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*Secretary-Treasurer,* Samuel Brown, M.D., 707 Race St., Cincinnati 2. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—Secretary-Treasurer, L. E. Wurster, M.D., 416 Pine St., Williamsport 8. The Society meets annually.

Philadelphia Roentgen Ray Society.—Secretary, Calvin L. Stewart, M.D., Jefferson Hospital, Philadelphia 7. Meets first Thursday of each month at 8:00 P.M., from October to May, in Thomson Hall, College of Physicians, 21 S. 22d St.

Pittsburgh Roentgen Society.—Secretary-Treasurer, Lester M. J. Freedman, M.D., 4800 Friendship Ave., Pittsburgh 24. Meets second Wednesday of each month at 6:30 P.M., October to May, inclusive, at The Ruskin, 120 Ruskin Ave.

ROCKY MOUNTAIN STATES

Rocky Mountain Radiological Society (North Dakota, South Dakota, Nebraska, Kansas, Texas, Wyoming, Montana, Colorado, Idaho, Utah, New Mexico).—*Secretary,* A. M. Popma, M.D., 220 North First St., Boise, Idaho.

SOUTH CAROLINA

South Carolina X-ray Society.—Secretary-Treasurer, Robert B. Taft, M.D., 103 Rutledge Ave., Charleston 16.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—Secretary-Treasurer, J. Marsh Frère, M.D., 707 Walnut St., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Dallas-Fort Worth Roentgen Study Club.—Secretary, X. R. Hyde, M.D., Medical Arts Bldg., Fort Worth, Texas. Meetings on third Monday of each month, in Dallas in the odd months and in Fort Worth in the even months.

Texas Radiological Society.—Secretary-Treasurer, Asa E. Seeds, M.D., Baylor Hospital, Dallas.

VIRGINIA

Virginia Radiological Society.—Secretary, E. Latané Flanagan, M.D., 215 Medical Arts Bldg., Richmond 19.

WASHINGTON

Washington State Radiological Society.—Secretary-Treasurer, Thomas Carlile, M.D., 1115 Terry Ave., Seattle. Meetings fourth Monday of each month, October through May, at College Club, Seattle.

WISCONSIN

Milwaukee Roentgen Ray Society.—Secretary-Treasurer, C. A. H. Fortier, M.D., 231 W. Wisconsin Ave., Milwaukee 3. Meets monthly on second Monday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, S. R. Beatty, M.D., 185 Hazel St., Oshkosh. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 414 N. Charter St., Madison 6. Meets first and third Thursdays, 4 to 5 P.M., September to May, inclusive, Room 301, Service Memorial Institute.

CANADA

Canadian Association of Radiologists.—Honorary Secretary-Treasurer, J. W. McKay, M.D., 1620 Cedar Ave., Montreal.

La Société Canadienne-Française d'Electrologie et de Radiologie Médicales.—General Secretary, Origène Dufresne, M.D., Institut du Radium, Montreal. Meets on third Saturday of each month.

CUBA

Sociedad de Radiología y Fisioterapia de Cuba.—Offices in Hospital Mercedes, Havana. Meets monthly.

ROENTGEN DIAGNOSIS

The Head and Neck

The Chest

The Digestive System

The Suprarenals

The Skeletal System

Gynecology and Obstetrics

The Genito-Urinary System

The Blood Vessels

Endocrinology

Foreign Bodies

RADIOTHERAPY

Neoplasms

Non-Neoplastic Diseases

Radiation Effects

Among the abstracts in this issue are some from Acta Radiologica for 1942, issues of that journal for the War years having just become available. While it is the policy of Radiology, so far as possible, to abstract papers within nine or ten months, at most, of their original publication, it has seemed worth while to bring to our readers this somewhat older material which might not otherwise come to their attention. More abstracts from this important radiological publication will appear in forthcoming issues. It is hoped that other foreign journals, also, may soon be represented in these pages.

diac lesions were observed, the most important being malignant neoplasms, with an incidence of 0.6 per cent, and cardiovascular disease, seen in 14.4 per cent of those examined. Fluoroscopy precedes clinical examination, and the fluoroscopic report is immediately available to the examining physician. This is one advantage of fluoroscopy over film methods in a large general clinic. L. W. PAUL, M.D.

Intrathoracic Metallic Foreign Bodies. A. L. d'Abreu, J. W. Litchfield, and C. J. Hodson. Lancet **2**: 265–268, Aug. 26, 1944.

In a group of 264 patients with severe chest wounds, seen at a forward general hospital within two to fifty days of the injury, there were 92 with retained intrathoracic missiles (excluding shell fragments or bullets superficial to the rib plane). Because of the danger of infection, hemorrhage, and structural damage, it has been the authors' practice to remove fragments measuring 1 cm. or more unless the anatomical approach involves too great a risk. Of the 50 patients in this series operated upon, 48 made a good recovery. Foreign bodies were removed from the lung in 25 cases, with one death; from the pleural cavity in 14; from the mediastinum or pericardium in 7; and from the endothoracic fascia in 4. One retained intracardiac missile lay in the interventricular septum and was not removed; the patient died. The most common complication on admission was pleural infection; 10 patients, subsequently operated upon for removal of the missile, arrived with this condition established. Lung abscess was seen in 5 cases; 2 of these patients died from secondary hemorrhage without operation.

Roentgenography plays an important part in assessing the suitability of patients for operation. It assists in determining the exact anatomical location and size of the foreign body, the state of the pleura and lung, and the amount of damage along the track of the missile. Posterio-anterior and lateral films are first taken, using deep penetration if necessary because of effusion, lung contusion, or atelectasis. For intrapulmonary missiles these views usually suffice, and the exact position of the missile in relation to heart, hilum, or lobes of the lung can be determined. It is especially useful to know whether the fragment lies near a fissure and to which lobal surface it seems closest.

For investigation of metal fragments lying close to the chest wall, the diaphragm, or heart, fluoroscopy is the method of choice. The underlying principle is so to position the patient that the central ray of the x-ray beam passes tangentially to the parietes at the site of the foreign body. Only thus can it be determined whether the missile lies within or without the chest. The same holds good for the diaphragm, and a tube that can be angulated tangentially to the dome of the diaphragm is invaluable in determining the position of missiles relative to it. In the region of the paravertebral gutter, it may be impossible, owing to the thickness of tissue, to say definitely where the missile lies, but enough information can be provided to enable the surgeon to proceed with exactness.

Estimated distances from the mid-line and the rib level, posteriorly or anteriorly, are helpful. When missiles lie in, or just outside, the rib plane, they are located with a needle under the fluoroscopic screen before operation. Only if paracardiac foreign bodies cannot be separated from the heart outline by a thorough all-round-heart tangential screening is it safe to assume their presence within the pericardium or heart wall. Very small intracardiac foreign bodies were twice missed on the film (because their movement blurs the shadows they cast) and were revealed only on fluoroscopy.

Roentgenography should give the surgeon an accurate account of the difficulties he is likely to meet. Rib damage, effusion, pleural fibrin deposit, collapse, lung contusion, missile track, the proximity of bronchi or calcified nodes (easily mistaken for foreign bodies at operation) are the most important conditions to assess. For example, the presence of strong adhesions or a tough "missile track" may necessitate an entirely different method of approach. On the other hand, localization of the foreign body at operation may be greatly facilitated by finding a "track" leading down to it. Again, when a lobe collapses, the position of a foreign body in it may be altered by a matter of inches.

By careful study of the course of the missile from its entry to its position of rest, the damage may be estimated with fair accuracy. Thoracotomy is often used for repairing injury to rib or diaphragm, as well as for removal of the foreign body.

In 4 cases, the foreign body was not easily found at operation. In these cases, fluoroscopy was done in the operating room and the foreign body localized by means of parallax and an opaque instrument or by passing a needle down to it.

The approach chosen for removal of missiles in the lungs depends largely on the roentgen findings and the state of the pleura. Classical thoracotomy, anterior thoracotomy, subcapsular thoracotomy, and a small intercostal incision have been employed. After removal of lung missiles the pleural cavity is not drained unless infection was present before operation.

Missiles lodging in the endothoracic fascia may give rise to an extrapleural hemothorax. This condition has occurred eleven times in this series. It is commonly associated with fracture of ribs by missiles with or without pleural penetration. An effusion as large as ten to twenty ounces may be present. Roentgenological characteristics of extrapleural hemothorax are: The effusion is almost always localized to a part of the chest wall, without spreading diffusely up or down it. It may arise gently or steeply at its periphery. In 2 of the authors' cases it appeared "overhanging" at its lower edge. It may indent the lung for several centimeters. When viewed at right angles to the plane of its base, it appears as a diffuse shadow, but in the later stages it may have a well defined border. It usually casts a dense shadow and may be accompanied by an intrapleural effusion. When situated in the region of the apex it has a tendency to lie over it like a cap. In size it may vary from a small "blister" to a large rounded collection 15 cm. across its base. There is almost always damage to adjacent ribs.

Many of the 264 cases forming the basis of this paper are included in the series of 260 "major complications of penetrating wounds of the chest" analyzed by the same authors in an earlier issue of the Lancet (2: 197 Aug. 12, 1944).

Primary Atypical Pneumonia. Report of Forty-Seven Cases. Don W. Chapman. J. Iowa M. Soc. 34: 391–395, September 1944.

Forty-seven cases of atypical pneumonia are analyzed, the data being presented in the form of a table

The author's observations are similar to those reported by others.

Roentgen Aspect of Atypical or Virus Pneumonia. Russell W. Bernhard. J. Iowa M. Soc. 34: 395–102, September 1944.

Six cases of atypical pneumonia are reported, each illustrated by several successive roentgenograms. In one of these cases roentgen therapy was given—three doses of 100 r (200 kv., Thoraeus filter, h.v.l. equivalent to 1.95 mm. Cu) to the anterior chest, on successive days. The patient, who had been extremely ill, showed an excellent response.

Atypical Pneumonia: A Diagnostic Problem in the Tropics. Philip A. Tumulty. Bull. Johns Hopkins Hosp. 75: 269–302, November 1944.

Ninety-three cases of atypical pneumonia seen in a U. S. Army General Hospital on an island of the Fiji group from Oct. 1, 1942, to April 1, 1944, are analyzed. The disease occurred sporadically throughout a large number of different units. Its course was characterized by mildness, with no deaths or complications. Great difficulty was encountered in its early diagnosis because of the complete absence in many cases of historical data and physical abnormalities suggesting pulmonary involvement. The disease was frequently confused with the common respiratory infections and also with commonly occurring tropical diseases, notably dengue and malarial fever. The diagnosis in all cases was finally established by roentgenography.

Four commonly recognized types of roentgen changes were seen: (1) patchy areas of infiltration, of density varying from snowflake to cotton ball appearance; (2) homogeneous areas of infiltration, possibly the result of the confluence of patches, judging from the appearance of the edges of these lesions; (3) infiltration, chiefly in the form of strands, beginning at or near the periphery of the lung fields and converging toward the hilum. These three types of change were invariably limited to a segment of one or more lobes, never involving an entire lobe. Occasionally the only alteration observed was (4) an increase in the prominence of one root shadow without significant parenchymal involvement. Some cases exhibited a combination of two or three of the above types, and in one case all four were observed.

Emphasis is laid upon the value of frequent re-examination as the chief aid in making a differential diagnosis clinically. Although personal contact evidently was important in the transmission of the disease, the suggestion is made that some non-human factor may also have played a part.

Primary Atypical Pneumonia as Seen in the Tropics. Harlan F. Haines and Clark M. Forcey. M. Clin. North America 28: 1490–1496, November 1944.

This is a report of 40 cases of primary atypical pneumonia observed among American troops on a small island in the South Pacific. The disease was mild and the findings were comparable to those reported by authors elsewhere.

Rib Fractures in Atypical Pneumonia. Rolfe M. Harvey. Am. J. Roentgenol. 52: 487–493, November 1944.

In a consecutive series of 500 cases of atypical pneumonia occurring in a station hospital, 19 patients had evidence of recent rib fractures. In only one was there a definite history of trauma. A large number of these fractures were missed on the original examination. They were seen later on serial examination of the chest for progress of the pneumonia, after callus had formed. All could have been detected on careful study of the roentgenograms.

The fractures almost invariably occurred in the region of the interdigitations of the muscle fibers of the serratus anterior and the obliquus externus abdominis muscles. All were in the anterior axillary or midaxillary line. Half of the patients affected had multiple fractures It is thought that the mechanism of production is due to opposing forces of the serratus anterior and the obliquus externus abdominis muscles attendant on the strain of coughing. In no case was there any apparent lack of calcium in the bones which could account for the occurrence of the fractures.

Excessive chest pain occurring in cases of atypical pneumonia should direct the search of the roentgenologist toward this complication. It may explain many supposed cases of pleurisy in atypical pneumonia.

The literature on spontaneous rib fracture is reviewed. Reports of cases from the author's series are also given, with reproductions of roentgenograms.

CLARENCE E. WEAVER, M.D.

Early Diagnosis of Pulmonary Tuberculosis. A Review of Cases Revealed in Recruits by Radiological Examination. E. K. MacLeod. New Zealand M. J. 43: 237–240, October 1944.

Roentgen examination of more than 100,000 army recruits in New Zealand revealed pulmonary tuberculosis, previously unsuspected, in 0.24 per cent, a figure which compares favorably with those obtained elsewhere.

Acute Bronchiolitis in Infants. Edward L. Pratt. M. Clin. North America 28: 1098–1107, September 1944.

Acute bronchiolitis is an infection of the lower respiratory tract, characterized by the following signs and symptoms: (1) slight malaise and mild irritability progressing more and more rapidly to marked restlessness and great distress, followed by apathy and grave illness; (2) cough and rapid respirations becoming more labored, with inspiratory retractions and prolonged, wheezing expirations; (3) evidence of inflammation of the nose, throat, and ears without significant involvement of the larynx; (4) hyperresonant lung fields in which the breath sounds are diminished; fine dry râles and varying numbers of musical râles widely distributed, although sometimes partially obscured by coarser moist and musical râles.

Chest roentgenograms reveal certain characteristic changes, the most uniform alteration being emphysema involving all portions of the lungs. Bulging of the emphysematous tissue into the interspaces is a prominent feature. Bronchovascular markings are increased, and there is peribronchial infiltration of varying degree. Small patches of pneumonic consolidation or atelectasis may be seen close to the hila and toward the bases. Close inspection of the films reveals irregularity of aeration, due to different degrees of bronchial and bronchiolar plugging, with multiple small areas of emphysema surrounded by normal or partially atelectatic lung tissue. Fluoroscopy is apt to be deceptive, since the lung fields appear unusually

bright and no large areas of increased density are seen. The diaphragm is depressed and moves very little, and the thoracic cage appears to be fixed in the position of extreme inspiration.

The treatment of acute bronchiolitis is directed toward the infection, the respiratory distress, the oxygen lack, and the circulatory collapse. The methods used in combating these disturbances are outlined.

Rôles of Medicine and Surgery in the Management of Bronchiectasis. John Alexander. Ann. Int. Med. **21:** 565–579, October 1944.

The primary cause of bronchiectasis is obstruction of varying degree in the larger bronchi, due to a foreign body, bronchial carcinoma or adenoma, tuberculous granulation tissue or fibrous stricture in the bronchial wall, pyogenic granulation tissue, or extrabronchial pressure by enlarged lymph nodes or other tumors. Important secondary causes are infection of the bronchial walls beyond the site of obstruction, varying degrees of atelectasis, and sometimes parenchymal fibrosis. Bronchial pneumonia is widely recognized as the most frequent initial lesion leading to bronchiectasis.

Many theories have been advanced to explain the mechanism of the development of bronchiectasis. Probably the most satisfactory is the following. Poor pulmonary ventilation results in the stagnation of viscid secretions in the small bronchi; patchy or lobar atelectasis then occurs; the highly negative intrathoracic pressure and, particularly, the pull of inspiration are not absorbed by the inelastic atelectatic part of the lung and so are transmitted to the bronchi, which dilate. If the bronchial walls become infected as a result of the stagnation of secretions (from inadequate ventilation and swelling of the mucosa), the walls become weakened and are likely to remain dilated even after the atelectasis has disappeared.

The diagnosis of bronchiectasis is suggested by the history, symptoms, physical signs and the roentgenographic and bronchoscopic findings. Almost without exception, however, an absolute diagnosis depends upon iodized oil bronchograms. Plain roentgen films show a diversity of shadows frequently confused with tuberculosis, congestive heart failure, atelectasis, bronchiogenic carcinoma, etc. Prior to instillation of iodized oil, lateral, postero-anterior, and stereoscopic films are taken to ascertain in advance as much as possible about whatever abnormal shadows are present.

Iodized oil should not be introduced into the lung within three weeks following the disappearance of an attack of acute pneumonitis or any febrile episode which presumably had its origin in the pulmonary lesions. The breaking of this rule may result in a serious (occasionally fatal) attack of acute pneumonitis.

The persistence of a filling defect in any bronchus proximal to the fourth order in two or more series of bronchograms is of the greatest clinical significance, since such a filling defect indicates not only that there is a probably harmful bronchial obstruction, but also that bronchiectasis presumably exists in the pulmonary segment beyond the obstruction.

A mere list of the complications indicates the potential gravity of bronchiectasis: repeated attacks of acute suppurative pneumonitis; pulmonary abscess or gangrene; septicemia; pleural empyema; spontaneous pneumothorax; brain abscess or meningitis; repeated severe hemoptyses; pulmonary fibrosis, emphysema, cor pulmonale, myocardial degeneration, cardiac decompensation; nephritis and amyloid disease; suppurative pericarditis; arthritis, and carcinoma from metaplasia of chronically inflamed bronchial mucosa.

The aim of treatment is to reduce, as far as possible, the ill effects of the permanent lesions by non-surgical means, or to remove the lesions completely by lobectomy. The latter is overwhelmingly the treatment of choice for those patients (1) whose age, cardiorespiratory functional reserve and general condition are suitable; (2) whose lesions are restricted to one lobe or to the right lower and middle lobes, or to the left lower and lingular ("left middle") lobes or, in some cases, to all the lobes of one lung (total pneumonectomy) or to one lobe of each lung or to two lobes of one lung and one lobe of the other lung (bilateral lobectomy); (3) who have failed to attain a satisfactorily stable condition of improvement from non-surgical treatment.

Postural drainage is the most valuable of the non-surgical measures. Its aim is to improve bronchial drainage, thereby lessening toxic absorption from retained bronchopulmonary secretions and reducing infection in the bronchi and lung.

Every bronchiectatic patient should have at least one bronchoscopic examination, not only because some otherwise undetectable intrabronchial lesion may be discovered but also because the aspiration of secretions and the chemical shrinkage of the bronchial mucosa often bring about improvement in the symptoms which in occasional cases is astonishingly great. Bronchoscopy is also of value in preventing the development of bronchiectasis in early cases of pneumonitis or "unresolved pneumonia."

Measures that promote expectoration are beneficial. The usual expectorants and the inhalation of a nebulized spray of a 1:100 dilution of epinephrine solution may prove useful if the secretions are thick and especially viscid.

Treatment of infection in the nasal sinuses, nose, mouth, and pharynx may improve the bronchiectatic symptoms. The author does not recall a single case, however, in which so-called radical sinus surgery carried out in the presence of troublesome bronchiectasis has either completely cured the sinus disease or importantly improved the symptoms of bronchiectasis. STEPHEN N. TAGER, M.D.

Eosinophilia with Pulmonary Disease on Return from the Tropics. J. Apley and G. H. Grant. Lancet **2:** 308–309, Sept. 2, 1944.

A considerable eosinophilia, associated with a cough and a transient pulmonary infiltration, was encountered in an Englishman returning from Bengal. The eosinophilia increased after an attack of acute febrile bronchitis in England. Löffler's syndrome and tropical eosinophilia are compared and it is suggested that the two conditions are not clearly distinguishable.

Löffler's account of the x-ray findings in the chest emphasized the transitory nature of the shadows, and Weingarten (Lancet 1: 103, 1943) has stated that in tropical eosinophilia "the mottling rarely lasts more than four weeks." This is, however, not invariably true, since Emerson (U. S. Nav. M. Bull. 42: 11[illegible] 1944) recorded a case in which the shadows had actually increased after three months before beginning to clear following arsenical treatment. "Thus," say the authors, "from the mildest case of Löffler's syndrome t[illegible]

the most severe cases of tropical eosinophilia, there is a gradation in the duration of the shadow."

Spontaneous Pneumothorax and Bronchial Asthma. Hugo T. Engelhardt and Vincent J. Derbes. Ann. Int. Med. 21: 711–718, October 1944.

The physical signs of pneumothorax associated with asthma do not differ from those of other etiology. Pain, cough, dyspnea, and shock are found. Fremitus, and breath and voice sounds are suppressed. Hyperresonance and displacement of the heart are often demonstrable. The roentgen examination is the *sine qua non* of diagnosis and without its aid many minimal cases would be overlooked. The main point in the differential diagnosis is the exclusion of the tubercle bacillus as the etiologic agent.

The authors report a case in a 48-year-old man complaining of severe dyspnea of three weeks' duration. He gave a history of recurrent attacks of asthma following pneumonia a year and a half before admission. A roentgenogram of the chest showed 50 per cent collapse of the right lung and mottling in the first interspace on the left. The patient was thought to have a right pneumothorax and bronchial asthma. Thoracentesis was done, and 200 c.c. of air were withdrawn from the right hemithorax. On the third hospital day a blowing sound was heard over the right side of the chest, indicative of a possible bronchopleural fistula; 1,300 c.c. of air were withdrawn from the chest on this day. Death occurred two days later.

Autopsy showed no enlargement of the heart. The right lung weighed 550 gm., and the left 390 gm. The former was small and somewhat wrinkled on its surface, which was marked by fibrous adhesions and occasional emphysematous blebs. The pleura was thickened by dense scar and fibrous tissue. In the majority of the sections the alveoli were partially collapsed. All the bronchi were dilated, the fibrous tissue around them being hypertrophied and heavily infiltrated with lymphocytes.

The authors point out that if the spontaneous pneumothorax accompanying asthma were due to an erosion process, it would be followed by pleural infection and pyopneumothorax, but this is not the case. They account for the collapse by the intermediation of a valve vesicle (congenital, emphysematous, or cicatricial). With each respiratory cycle the positive pressure increases in the vesicle because the nature of the lesion allows air to enter more easily than to leave. In this manner a vicious cycle is initiated, so that the pleural covering of the vesicle becomes progressively thinner and, because of diminished blood supply, devitalized. Then, without any appreciable strain, the vesicle tears and a greater or lesser degree of pneumothorax results.

The danger of rupture may be considered greater on deep inspiration than on coughing, since atmospheric pressure is present within the alveoli and a negative pressure without. During coughing, the tendency is toward the closer approximation of the chest wall to the lung, resulting in a decrease in negativity in the intrapleural space and a lessening of the positive pressure in the alveoli. Both these factors act to preserve the integrity of the vesicle. Coughing, however, could tear the lung in marginal zones where the pressure is unequal.

Whereas spontaneous pneumothorax can happen at any age, it usually occurs in early adult life, when negative intrapleural pressure is greatest. The elastic recoil of the lung is greater in youth, the action of the diaphragm is more efficient, and the degree of emphysema is less.

The prognosis in pneumothorax complicating asthma is good, the vast majority of cases going on to recovery with a minimum of therapy or none, provided the patient is not in an acute asthmatic attack.

The removal of air from the pleural space is strongly contraindicated for three reasons: (1) the equality of pressure within and without the alveolus facilitates healing of the torn vesicle; (2) removal of air and the production of a negative intrapleural pressure favor the formation of a bronchopleural fistula, from which a chronic pneumothorax or a tension pneumothorax may result; (3) the existence of a fistula favors the contamination of the pleural space. Tension pneumothorax appears to be the one indication for thoracentesis. Here action is imperative to relieve respiratory distress. After the site of rupture has healed, the use of air-oxygen mixtures where the concentration of oxygen approaches 100 per cent may be of real value.

STEPHEN N. TAGER, M.D.

Pulmonary Cysts. David G. Pugh. Am. J. M. Sc. 208: 673–681, November 1944.

This paper, appearing under the heading "Progress of Medical Science," is in the nature of a review.

Since the etiologic factors are varied, and perhaps not completely understood, the author believes that pulmonary cysts are probably best classified from a roentgenologic point of view; that is, on the basis of size, shape, number, and distribution. He quotes Sellors' classification (Tubercle 20: 49, 114, 1938).

Some pulmonary cysts, particularly the "balloon" or "distention" type, which occur in newborn infants, are probably congenital in origin. In the light of studies which indicate that the development of the permanent pulmonary parenchyma of the adult occurs after birth, taking from three to fourteen years for its completion, it is probable that the origin of many pulmonary cysts should be considered "developmental" rather than "congenital." Disturbance in the development of the lung, notably infection in early life, may result in persistence of the primitive infantile type of lung. The bronchi in such a lung may become stretched and distended, and bronchiectatic and cystic structures may occur, depending on whether the bronchi remain patent or become shut off at the proximal end.

It has been emphasized recently that pulmonary cysts are frequently acquired, as the sequelae of bronchitis or bronchopneumonia. A pneumatocele may start as acute lobular emphysema. A check-valve obstructing the bronchial lumen may be due either to non-resolution of the initial inflammation or to a subsequent distortion of the dilated air spaces. In infants with pneumonia there have been reported lesions which resemble congenital cysts, but which are really due to regional obstructive pulmonary emphysema. These usually disappear spontaneously.

Cysts may produce symptoms through the following mechanisms: (1) There may be respiratory embarrassment due to loss of lung tissue owing to the expansion of the cyst, compression of the remaining lung, and mediastinal displacement. (2) Infected cysts may cause symptoms of pulmonary suppuration. (3) There may be enlargement of the right side of the heart and cardiac failure.

Pulmonary cysts are to be distinguished from emphysematous bullae and tension pneumothorax. Infected cysts must be differentiated from lung abscess, tuberculous cavitation, empyema, and cavernous bronchiogenic carcinoma.

Bronchography is not considered to be of much assistance in cases of cystic lung, although it has been used in the attempt at differentiation from empyema. It may also be used to determine the extent and site of cystic bronchiectasis. BENJAMIN COPLEMAN, M.D.

Congenital Absence of the Lung (Agenesis) and Other Anomalies of the Tracheobronchial Tree. Charles F. Ferguson and Edward B. D. Neuhauser. Am. J. Roentgenol. 52: 459–471, November 1944.

Agenesis of the lung has been encountered so rarely that only about 50 examples have been recorded in the medical literature. The authors have seen 5 cases of this developmental anomaly during the past six years. All 5 were diagnosed during life by bronchoscopic examination followed by lipiodol roentgenograms of the tracheobronchial tree. Four patients are still living.

Males are more commonly affected, though 3 of the authors' patients were females. The left lung is more frequently absent than the right. As to cause, the theory of a developmental error of endogenous origin seems most logical. A great number of cases show coincidental anomalies, such as a narrowed trachea, extra cartilaginous rings, supernumerary bronchi of the normal lung, absence of the pleura on the affected side, tracheo-esophageal fistula, esophageal stenosis, and synostosis of various ribs. In addition, more distant congenital abnormalities have been recorded. Each of the authors' patients had some other developmental anomaly.

Anatomically three types of agenesis are recognized, depending on the age at which the developmental defect occurred in the embryo: (1) true aplasia—cases in which there is no trace of a lung, bronchus, or vascular supply to the affected side; (2) cases in which there is a tiny out-pocketing of the trachea; that is, a primordial bronchial bud, but no lung tissue; (3) extreme hypoplasia, in which the bronchus is fully developed, but reduced in size, ending in a fleshy structure without lobes, which lies in the mediastinum. Most cases fall in the first category—true aplasia.

Symptoms are variable or may be altogether lacking. In practically every case the potentially vacant space in the chest is filled with displaced heart, thymus, and other mediastinal contents. The roentgenograms generally show a dense homogeneous shadow on the affected side, with displacement of the heart and mediastinum to that side and with elevation of the diaphragm and narrowing of the intercostal spaces. Bronchoscopy is the only rational and final method for accurate clinical diagnosis. Lipiodol injection at the time of bronchoscopy should solve the problem.

Prognosis should always be guarded, although the condition is compatible with longevity. In cases of persistent emphysema or atelectasis, or cases of supposed unresolved pneumonia or recurrent pneumonia in the same lobe, congenital anomalies of the tracheobronchial tree must be considered.

Case histories of five patients with agenesis of the lung are presented, accompanied by roentgenograms and bronchograms. Bronchograms of five cases of tracheobronchial tree anomalies are also presented.

CLARENCE E. WEAVER, M.D.

Abscesses of the Lung in a Premature Baby. William Leach and Mark Holland. Am. J. Dis. Child. 68: 324–326, November 1944.

The authors' patient was a six weeks premature infant seen at the age of two and a half months. Delivery had been normal, and the child appeared to be thriving when an intermittent fever developed, with an unproductive cough. Examination showed signs of pneumonia in the right lung and sulfathiazole therapy was instituted. Symptoms and signs increased in severity during the next forty-eight hours with but little rise in temperature. Thoracentesis produced 20 c.c. of thick pus which contained staphylococci. A second aspiration, six days later, following a severe unproductive spasm of coughing, yielded 30 c.c. of similar material. A chest roentgenogram at this time showed little evidence of pleural fluid and revealed three large circular areas of decreased density with rather thick walls, apparently cavities, occupying most of the right lung. A second roentgenogram, three weeks later, showed the cavities to be slightly smaller, with no pleural reaction. Clearing thereafter was progressive, so that only accentuation of the peribronchial markings in the middle part of the right lung remained after eight months.

The authors assume these lesions to have been pulmonary abscesses, although no fluid levels in the cavities were ever described nor can they be detected in the excellent roentgen reproductions. In addition, there was no history of preceding upper respiratory disease, foreign body aspiration, or operative procedure.

LESTER M. J. FREEDMAN, M.D.

Pulmonary Disease Associated with Mega-Esophagus. H. Stephen Weens. Am. J. Roentgenol. 52: 472–480, November 1944.

A review of the literature reveals little attention to the occurrence of pulmonary lesions accompanying mega-esophagus. During the past four years the author has observed 15 cases of this latter disorder and in 5 of these cases pulmonary disease was demonstrated roentgenologically. One patient had an abscess in the upper right lobe. Another showed the presence of acute and chronic pulmonary disease consisting of aspiration pneumonitis and interstitial fibrosis. In a third case there was diffuse interstitial pulmonary fibrosis. A fourth patient had aspiration pneumonitis in both lung bases. In the fifth patient there was an associated bronchiectasis.

It should be emphasized that the digestive disturbances of mega-esophagus, especially in the presence of respiratory symptoms, may appear so slight to the patient that he will frequently conceal their presence. Among the roentgen evidences of mega-esophagus is widening of the mediastinal shadow toward the right side, extending from the base of the neck to the diaphragm. A fluid level in the esophagus is a helpful sign. Another observation of great significance is a double air column overlying the upper dorsal spine in the postero-anterior view. The central air column represents the trachea, which is seen through the air column of the upper dilated esophagus.

In all patients with mega-esophagus, the presence of pulmonary disease should be suspected and searched for. Similarly, in patients with pulmonary disease of unknown etiology, the presence of mega-esophagus should be taken into consideration. It is believed that the pulmonary lesions are the result of aspiration of esophageal contents.

Five case reports with reproductions of roentgenograms are given. CLARENCE E. WEAVER, M.D.

Pulmonary Suppuration Secondary to Cardiospasm. I. Bird-Acosta. Am. J. Roentgenol. 52: 481–486, November 1944.

There are numerous causes of esophageal retention. Of these, cardiospasm, though a fairly common clinical entity, is rarely considered when an explanation is sought for a chronic pneumonitis of unknown origin. The pulmonary suppuration is the result of esophageal overflow and aspiration of esophageal contents. Three cases of this nature are described in detail, and reproductions of roentgenograms are included.

CLARENCE E. WEAVER, M.D.

Scrub Typhus. Results of a Study of the Cases of Two Hundred Patients Admitted to and Treated at a Station Hospital between Feb. 9, 1943, and Feb. 4, 1944. Bernard L. Lipman, Adrian V. Casey, Robin A. Byron, and Edwin C. Evans. War Med. *6*: 304–315 November 1944.

This comprehensive paper on scrub typhus, based on a series of 200 cases treated in the Southwest Pacific area, includes a section on pulmonary complications which should be of interest to radiologists. In the majority of the patients the earliest observed pulmonary abnormality was inspiratory and expiratory sonorous râles, occasionally associated with a mild degree of cyanosis. In 20 per cent of the series physical signs of bronchitis developed during the course of the disease. These included harsh breath sounds, a few scattered râles, and cough, productive of some mucopurulent sputum, which was occasionally blood-tinged. Roentgen examination in such cases either revealed no abnormality or showed increased bronchovascular and hilar markings. The bronchitis may overshadow an underlying rickettsial pneumonitis, such as exists in Q fever. With the subsidence of the fever and concomitant clinical improvement, the signs of the bronchitis or pneumonitis disappear. Nine per cent of all the patients contracted bronchopneumonia, and this diagnosis was confirmed by roentgen examination. Four per cent of the total number acquired lobar pneumonia with typical physical signs. Five per cent of the patients had pleural effusion, bilateral in 2. Three patients had bronchial asthma during the course of the disease; none of these had previously experienced asthmatic attacks. Large pulmonary emboli proved fatal in 2 cases. Lobar atelectasis occurred once, in a patient with a chest wound.

Mediastinal Emphysema Resulting from Exposure to a Pulmonary Irritant. Raymond W. Monto and Paul S. Woodall. War Med. 6: 251–252, October 1944.

A case of mediastinal emphysema in a young man, resulting from exposure to chlorine gas, is reported. The diagnosis of interstitial emphysema was established by the characteristic crunching sounds synchronous with the heart beat heard in the precordial area. It was confirmed by the roentgen finding of air at the base of the neck in the deep fascial planes.

Value of Roentgenologic Examination of the Heart. M. L. Sussman and A. Grishman. Am. Heart J. 28: 647–660, November 1944.

The authors present an angiocardiographic study of the heart contours in the normal subject and in those diseases in which there occurs predominant enlargement of a single chamber. The observations were confirmed in most instances by postmortem correlation.

Normally, in the postero-anterior position the right heart border is formed by the right auricle. At its junction with the supracardiac segment there is ordinarily some portion of the ascending aorta. The aortic valve is situated a variable distance within the cardiac silhouette. The lower left contour is formed by the left ventricle, and above this is the pulmonary artery. Between the two there is usually a small segment which is not demonstrable in the usual angiocardiogram but is thought to be the left auricular appendage. The pulmonary valve is also hidden in the cardiac silhouette. The pulmonary conus does not form part of the cardiac contour. In a few cases the descending branch of the left pulmonary artery may be projected so that its shadow merges with that of the pulmonary artery and actually forms the contour of the middle left cardiac segment. As the subject is rotated into the right anterior oblique position, the pulmonary artery forms the entire middle left arc. In the right lateral projection the pulmonary conus also forms part of the contour below the pulmonary artery. In the left anterior oblique position the right ventricle may constitute part of the lower anterior contour in some cases, but most often it is obscured by the right auricle. The lower left border in this position is formed by the left ventricle. The boundaries of the right ventricle cannot be identified in this view. The interventricular groove does not correspond to the position of the interventricular septum as seen angiocardiographically.

Right ventricular enlargement, which is characteristic of cor pulmonale, is indicated by prominence of the pulmonary artery segment even though radiologically the heart may not appear enlarged. In the absence of pulmonary artery dilatation, the only evidence of moderate right ventricular dilatation in emphysema is enlargement of the heart to the left, but this observation is useless unless clinical data exclude *left* ventricular dilatation and a pulmonary disease is present in which cor pulmonale might be expected.

The outstanding example of left auricular dilatation is seen in mitral stenosis. Roentgenologically a straightening or convexity of the middle left cardiac contour is observed in the postero-anterior and right oblique positions. The chamber may be demonstrable as a dense area within the cardiac shadow. Sometimes it projects to the right and overlaps the right auricular contour. In the right oblique and right lateral positions there is encroachment upon the retrocardiac space. The esophagus is displaced posteriorly and to the right and is compressed. Angiocardiograms show elongation, elevation, and anterior bowing of the pulmonary artery, but it is not ordinarily dilated to any significant degree. The right ventricle is also bowed anteriorly. Except when the left auricle is seen directly, the most accurate criterion of its size is the position of the esophagus.

Left ventricular enlargement may take the form of concentric hypertrophy with little or no dilatation (usually associated with hypertension) or eccentric hypertrophy with dilatation. In concentric hypertrophy the contour of the left ventricle is the basis of roentgen diagnosis. The outline becomes more rounded and with increasing hypertrophy there is also elongation of the ventricle. Concentric hypertrophy with dilatation is manifested first by an increase in the size of the left ventricle, particularly in its long diameter, accom-

panied usually by enlargement to the left and posteriorly. The authors are not in agreement with those who believe that, when the long diameter of the heart exceeds the transverse diameter by more than 10 per cent, enlargement of the left ventricle may be assumed, for the long diameter is not a true indication of the length of the ventricle. Therefore, until the increased volume is detectable by measurement of the whole heart, it is necessary to rely upon visual impression to ascertain whether the left ventricular contour is abnormal.

In their conclusion, the authors point out that the roentgen examination is only a part of the study of the heart. Only as the findings are considered critically in association with other clinical data do they become of real value. Alone they may be insignificant or even misleading. HENRY K. TAYLOR, M.D.

On the Circulation Through the Heart, the Big Vessels and the Pulmonary Circulation, Simultaneously Recorded by Cinematography and Electrocardiography. Nils Westermark. Acta radiol. **23**: 473–510, Oct. 31, 1942. (In English.)

This article, which assumes the importance and proportions of a monograph on the subject of cinematographic and electrocardiographic demonstration of circulatory phenomena, does not lend itself to adequate abstracting within the limited space of RADIOLOGY and should be read in the (English) original by anyone interested in this outstanding research work.

The author himself summarizes his experiments and findings as follows:

"By injecting thorotrast as the contrast medium the circulation through the heart and the big vessels has been recorded by roentgencinematography at a rate of 32 pictures per second. Electrocardiography has been simultaneously carried out. This permits the film pictures to be compared with the electrocardiograms with an accuracy of 0.03 sec.

"The circulation time through the lesser circulation has varied between 1.4–2.5 sec. with an average of 1.7 sec.

"The maximal circulatory rate in the pulmonary artery during systole is found to be 150–200 cm./sec. and in the aorta 350–650 cm./sec. The mean rate of flow during systole and diastole is 25–30 cm./sec. and 35/65 cm./sec., respectively.

"The circulation through the heart shows that the atrio-ventricular valves open at P and close immediately before Q. It is only during this period that the ventricle seems to fill up with blood. During this period the auricle empties itself only in part and apparently forms a blood reservoir holding large quantities of blood-rests. The auricle is getting filled up all the time, with a more rapid filling immediately after the T wave at the beginning of the diastole.

"The systolic contraction of the ventricle begins in conjunction with the QRS complex with a downward movement of the atrio-ventricular junction. In so doing the junction seems to bulge into the ventricle like a cone. The downward movement of the atrio-ventricular junction is probably caused by contraction of the interventricular septum. Then the ventricular wall begins to contract at the apex at the same time as the atrio-ventricular junction is seen to make a regressive movement between the S and T waves. During this period the space between the atrio-ventricular junction and the inner contour of the ventricular apex seems to be unaltered. The ventricular wall then continues its contraction successively up to the conus arteriosus.

"This progressive course of the contraction of the ventricle accords well with Lewis' investigations into the excitation of the ventricular wall, its distribution and duration.

"The semilunar valves do not seem to open until the beginning of T when the contraction wave through the ventricular wall reaches the conus and when the ventricular pressure has attained its maximum. The closure of the semilunar valves takes place at the end of T. The ventricle has then almost completely emptied itself and afterwards seems to stand under prolonged contraction holding a slight amount of blood-rests. At the P wave the ventricle is seen to relax and the atrio-ventricular valves to open at the same time as the next phase sets in.

"The different phases of contraction of the ventricle and auricle also seem to be reflected in the pressure curves from auricle, ventricle, and aorta."

ERNST A. SCHMIDT, M.D.

Rupture of Mitral Chordae Tendineae. Clinical and Pathologic Observations on Seven Cases in Which There Was No Bacterial Endocarditis. Orville T. Bailey and John B. Hickam. Am. Heart J. **28**: 578–600, November 1944.

The histories and pathologic observations in 7 cases of rupture of the mitral chordae tendineae unassociated with bacterial endocarditis are reviewed. All showed fibrosis and chronic injury of the mitral valve. In two, the lesions were those of rheumatic heart disease; in the remainder, the changes suggested quiescent rheumatic disease, but were not pathognomonic. The roentgen findings are of particular interest. In 2 of the 4 cases examined a moderate dilatation of the left atrium was observed. In neither of these cases was there a significant mitral stenosis at autopsy. In one case the left atrium exhibited a systolic pulsation. This is a sign of very brisk mitral regurgitation. Dr. M. C. Sosman, in a personal communication to the author, stated that he has noted this finding in two other patients who are still living and feels that it is strongly suggestive of rupture of the mitral chordae tendineae. If further study confirms this, the observation will be of great assistance in the diagnosis of the condition.

THE DIGESTIVE SYSTEM

Diagnostic Delay in Gastric Carcinoma. Gilson Colby Engel. Pennsylvania M. J. **48**: 126–129, November 1944.

More deaths are caused by cancer of the stomach than by cancer of any other organ of the body, deaths per 100,000 population being 29.6 as compared with 14.9 for cancer of the female genital organs and 10.4 for mammary cancer. In only 17 per cent of cases seen by the author is there any hope of cure, and this figure does not differ greatly from those of other clinics. "The finger of guilt," he says, "must point to delay"—delay in appearance of symptoms, delay on the part of the patient in seeking medical advice, delay by the physician in making a diagnosis and in seeking surgical consultation. To these causes of high mortality must be added inadequacy of surgical procedure.

The three chief diagnostic tests for early carcinoma of the stomach are gastric analysis, roentgenography, and gastroscopy. The author states that with nega-

tive x-ray findings and a positive history there is still a 25 per cent chance of an ulcer or carcinoma being present and that the chance of error in differentiating between a benign and a malignant lesion is about 50 per cent. Added to this possible error is the further fact that in about 80 per cent of gastric carcinomas the symptoms disappear on an ulcer regime. The accuracy of gastroscopic examination is given as about 75 per cent, and of gastroscopic and roentgen examination combined as 85 per cent.

The indications for operation are listed as follows:

1. Gastric lesion with low acidity.
2. Gastric lesion—middle age—loss of appetite—tired.
3. Gastric lesion—greater curvature of posterior wall.
4. Large prepyloric lesion regardless of acidity.
5. Fundal lesion or high lesser curvature lesion.
6. Obstructive gastric lesion.
7. Penetrating gastric lesion.
8. Gastric lesion with hemorrhage in patient over 45 years old.
9. Medically treated gastric lesion—four to six weeks' treatment and still a positive x-ray.

JOSEPH T. DANZER, M.D.

Diverticulitis of the Distal Colon. Harold G. Reineke. Ohio State M. J. 40: 939-941, October 1944.

Diverticula are the most common of all lesions of the large bowel. While usually of no immediate clinical importance, they may give rise to several secondary processes; of these, diverticulitis is the most important. Diverticula may be demonstrated either by the barium meal or by barium enema. If the clinical evidence points to the colon as the seat of the trouble, the enema study should be performed first. This materially lessens the danger of making a partial obstruction a complete one. The enema should be given under fluoroscopic guidance so that the contours and movements of the bowel can be studied from all angles. Spot films taken on the fluoroscopic table as the column of barium progresses sometimes furnish information not revealed by those of the completely filled colon. Post-evacuation films are of great value and will often show diverticula which were not seen when the colon was full. Failure of the diverticulum to fill immediately is attributed to swelling of its mouth or to the presence of bowel contents which prevent entrance of the barium.

A differential diagnosis between obstruction due to diverticulitis and that produced by carcinoma cannot be made roentgenologically, unless some of the barium passes through the constricted area. Carcinoma destroys the mucosa and produces a margin on which no mucosal pattern can be seen, while in diverticulitis the mucosal folds persist and are usually exaggerated. Serial roentgenograms are of great assistance. The constriction due to tumor remains unchanged in size and shape while the inflammatory constriction may vary from time to time in its more intimate detail. A cancerous constriction is usually relatively short and the adjacent walls, as a rule, fill out widely and flexibly; in diverticulitis the constriction is usually relatively longer and the adjacent gut is likely to be irritable. Diverticulitis and carcinoma rarely occur in the same person.

The patient with complete obstruction must have a cecostomy. Following this, he should again be examined roentgenologically in an attempt to arrive at the correct diagnosis. In some cases of diverticulitis, the inflammation has been found to subside and further surgery has been unnecessary.

Meckel's Diverticulum: Preoperative Roentgen Diagnosis. Glenn D. Carlson. Mil. Surgeon 95: 272-274, October 1944.

A case of Meckel's diverticulum, diagnosed preoperatively by roentgen studies, is presented. The author advocates the utilization of frequent roentgenograms and fluoroscopy during the four to six hours following the barium meal as affording greater opportunity for the demonstration of diverticula, abnormal mucosal patterns, and other intestinal variations. He believes that the number of small bowel lesions demonstrated is in proportion to the amount of time and study devoted to examination.

Diagnosis of Liver Abscess by Means of Thorotrast Hepatosplenography. Wallace M. Yater. J. A. M. A. 125: 775-778, July 15, 1944.

A brief discussion is presented of liver abscess, both amebic and pyogenic, with reference to the diagnostic efficacy of hepatosplenography following thorotrast injection. The adult dose of thorotrast is 75 c.c. and the x-ray exposures are made several hours after injection. Details of the technic are given. Reference is made to a previous study of 286 patients, on whom this procedure was used without harmful effects (Yater and Coe: Ann. Int. Med. 18: 350, 1943. Abst. in Radiology 41: 410, 1943).

The abscess is demonstrable as an area of lesser density than the normal liver tissue. Metastatic carcinoma also appears as an area of decreased density but is frequently surrounded by a halo of condensed liver tissue, which serves as a differentiating feature. Solitary tumors are unusual but present roentgenographic features similar to those of metastatic growths. The same is true of echinococcic and other rare cysts.

Five cases of probable amebic liver abscess and 2 of pyogenic liver abscess are presented. Unfortunately the reproductions of the roentgenograms are so poor that little benefit can be obtained from their study.

The author believes that increasing alertness to the possibility of amebic abscess will be necessary in the future because of the likelihood of its occurrence in service men returning from the tropics.

ROBERT S. MACINTYRE, M.D.
(University of Michigan)

Pancreatic Lithiasis with Associated Intestinal Hemorrhage. Report of a Case. Herbert Fanger. New England J. Med. 231: 678-680, Nov. 16, 1944.

A 63-year-old man had diffuse abdominal pain of one year's duration, with tarry and blood-streaked stools and a loss of 20 pounds in weight. The pain was not referred to the back nor did it show radiation. Blood studies and x-ray examination of the gastro-intestinal tract gave no information. At autopsy, an ulceration 4 mm. in diameter was found near the ampulla of Vater, filled with fresh clot, beneath which was a stone 3 mm. in diameter. Numerous smaller stones were found throughout the pancreatic ducts.

No adequate explanation for the formation of pancreatic stones has been offered and their etiology is unknown. Theoretically, pancreatic lithiasis should be seen on a scout film of the abdomen, but the ... ll

size and low calcium content of the stones probably explain the infrequency of this finding.

JOHN B. MCANENY, M.D.

THE SUPRARENALS

Two Cases of Sympathicoblastoma of the Suprarenal Gland with Metastases to the Cranium and the Tubular Bones. Thomas Rosendal. Acta radiol. **23**: 462–472, Oct. 31, 1942. (In English.)

Two cases of sympathicoblastoma, apparently originating in the suprarenal glands, with extensive osseous metastases are reported.

In the first case, in an 18-month-old boy, metastatic tumors were observed above the left orbit in the frontal bone, in the left mandible, and in the diaphysis of the left radius, as well as in the diaphyses of both femora, tibiae, and humeri. X-ray examination of the abdomen showed a large tumor in the left kidney region with evidence of some small irregular calcifications. The osseous changes were first interpreted as Ewing's tumor or, possibly, osteomyelitis, syphilis, or Schüller-Christian disease. Radiotherapy resulted in temporary improvement only. The microscopic diagnosis following necropsy was sympathicoblastoma of the suprarenal gland with metastases.

In the second case, in a one-year-old boy, fixed tumors in both temporal regions with bilateral exophthalmos were observed, and a large tumor in the right flank could be palpated. Roentgenograms of the cranium showed spicule formation at the bone surface in the temporal region and numerous small bone rarefactions in the right mandible. These bone changes were tentatively diagnosed as hemangioma. A large soft-tissue tumor was demonstrable in the right kidney region, containing numerous minute calcifications. Biopsy of one cranial tumor resulted in the diagnosis of sympathicoblastoma. Following radiotherapy, the bone spicules in the cranium disappeared and there was an improvement of the clinical symptoms, although roentgenographically the destructive bone changes seemed to increase. The patient was still alive at the time of publication (four months after radiotherapy).

Sympathicoblastoma, which seems to be invariably fatal, is rather rare. It has been described as (neurogenic) glioma by Virchow and as retroperitoneal sarcoma of the lymphosarcoma group by Dalton. The roentgenologic differential diagnosis is difficult, as demonstrated and discussed in both cases by the author. In addition to the diseases mentioned above (Ewing's tumor, osteomyelitis, syphilis, Schüller-Christian disease, hemangioma), Wilms' tumor, lymphosarcoma, ovarian tumor, leukemia, chloroma, periostitis, rickets, and other diseases must be considered.

ERNST A. SCHMIDT, M.D.

THE SKELETAL SYSTEM

Roentgenological Diagnosis of Skeletal Diseases of Infants and Children. (Russell D. Carman Lecture of Radiological Society of Minnesota.) Ralph S. Bromer. Minnesota Med. **27**: 895–904, November 1944.

Before discussing the characteristic bone changes in various children's diseases, the author warns against the careless use of the word pathognomonic in this connection. Signs that at one time were considered pathognomonic of a given condition have, with increasing application of roentgen diagnosis to skeletal lesions, been demonstrated in other disease processes as well. The conditions described in the ensuing pages include fetal and infantile rickets, late rickets, renal rickets, scurvy, lead poisoning, leukemia, the chronic hemolytic anemias, sickle-cell anemia, celiac disease, xanthomatosis, Gaucher's disease, and congenital syphilis. Not only does the author present the important roentgen features of each of these diseases, but by frequent reference to the literature he seeks to demonstrate the progress made in their diagnosis in the last two decades.

A reading of the article in the original is strongly recommended, for it does not lend itself to satisfactory abstracting. The zeal and enthusiasm which Bromer has given to the study of roentgen pathology in bone over a period of years are here reflected, as they are in the clarity and comprehensiveness of his many papers on the subject. Particularly has his work been a help in maintaining clear and definitive classifications of the various lesions.

PERCY J. DELANO, M.D.

Leontiasis Ossea Complicated by Marjolin's Ulcer. Observation of a Case for Twelve Years. Ray E. Burger and Edwin P. Lehman. Surgery **16**: 542–55?, October 1944.

Virchow applied the term *leontiasis*, which had been used to designate the nodular changes in the soft parts of the face of the leper, to cases presenting hyperostosis of the skull, adding the adjective *ossea*. The name leontiasis ossea is descriptive of the appearance only, not of the actual lesion, the nature of which is still undetermined.

Clinically the disease is characterized by slowly developing bony deformity of the face, usually beginning in early life. If the bony overgrowth impinges on the air passages or the cranial nerves, the syndromes generally known as craniostenosis result. The malady has been compared with acromegaly, but the latter involves the soft tissues as well as the bones. It has also been likened to Paget's disease, but that condition occurs at a more advanced age and is seldom localized to the head. Eden (Brit. J. Surg. **27**: 323, 1939) includes leontiasis ossea among the fibro-osseous tumors of the skull and facial bones under the general designation diffuse osteomas, regarding the lesions as true benign tumors, though he admits the possibility of infection and trauma as irritative factors. The characteristic changes are replacement of the bone marrow by fibrous tissue and, later, an excessive formation of new bone.

The disease usually affects the maxilla, malar bone, ethmoid and nasal bones; less frequently the sphenoid, parietal, and mandibular bones. The involvement may be unilateral or bilateral. Roentgenography reveals thickening and increased density of the bone of intense and uniform character. The surfaces of the affected bone are entirely smooth and sharply defined. The disease does not go beyond the anatomic margins of the bone or of a part of the bone if the latter has developed from more than one bony anlage.

The authors' patient was a man of 28, who had always had a very large lower jaw. This had caused him no discomfort until about six years before admission, when he began to experience pain and swelling of the jaw on the left side and to expectorate blood and pus. Some dead bone was removed at this time and the symptoms were relieved, but a salivary fistula remained. Five months before the present admission there was a

recurrence of the earlier complaints. The lower jaw was large and protruding, and the maxillae were prominent. The floor of the mouth was lengthened forward and many teeth were missing. Several sinuses from the infected left mandible opened through the mucous membrane, and a salivary fistula was present on the right. X-ray examination revealed a large mass of osteoid tissue projecting from the lower jaw at its anterior portion. The maxillae also showed dense new bone formation extending into the antra. No abnormality was seen in the calvarium, shoulder girdle, pelvis, or long bones. Laboratory examination was essentially negative. Two operations were performed on the left jaw for removal of necrotic bone, and several months later a sequestrum was removed.

After an interval of eleven years the patient was again seen. The jaw had meantime grown progressively larger and the tumor had increased in size, extending downward and resting on the chest. It now measured 32 × 22 × 22 cm. and presented large superficial ulcerations. The salivary fistula remained open. Part of the maxilla had sloughed, leaving a mucosa-lined communication between the mouth and the antra, which the patient kept closed with wads of tissue paper. X-rays revealed a tremendous increase in the size of the mandibular tumor, with involvement of the base of the skull and upper cervical vertebrae. Other bones showed no abnormalities except for an old fracture of the left femur.

The tumor was resected with considerable difficulty and the defect covered with skin flaps. The huge, stony hard mass measured 33 × 21 cm. and weighed ,035 gm. A fistula partially lined with epithelium connected the superior aspect of the specimen with a large irregular area of ulceration. The entire tumor was found to be composed of calcified material resembling cancellous bone with abundant pearly gray fibrous stroma. Many large areas of necrosis were seen. There was no evidence of the formation of bone marrow. The entire mass had the appearance of a benign bone tumor.

Sections of the buccal fistula and the adjacent ulceration revealed epidermoid carcinoma, grade 1. This the authors regard as of the same nature as Marjolin's ulcer occurring in chronic ulceration of the skin and chronic sinuses.

The patient did well for a while but ultimately died of recurrent carcinoma. J. E. WHITELEATHER, M.D.

Pantopaque: Notes on Absorption Following Myelography. George M. Wyatt and Roy G. Spurling. Surgery 16: 561–566, October 1944.

Lipiodol and the gases formerly used for myelography by the Army Medical Corps have been replaced by pantopaque, its chief advantage being that it is absorbed rather than remaining as a persistent foreign substance in the subarachnoid space. The study reported here was prompted by observations at the Walter Reed General Hospital suggesting that this absorption might not be so rapid in all patients as was previously believed.

Follow-up roentgenograms were obtained for 6 patients in whom the removal of pantopaque had been incomplete. The films included the skull and entire spine and sacrum to exclude the possibility of migration of the contrast material. As judged by the x-ray shadows, there was a definite decrease in the amount of residual pantopaque in all cases. The size and density of the r[illegible] due to absorption of the entire compound rather than of iodine only. In several instances minute residual droplets were as opaque to the x-ray as larger droplets seen immediately following incomplete removal. If the decrease in density revealed by x-ray were due to the absorption of iodine from the compound rather than absorption of the total mass, the remaining small collections would have lost their radiopacity.

Absorption was usually most rapid during the first few months following injection. The small remaining droplets were absorbed at a relatively slower rate. The variations in the rate of absorption and in the density of the residual droplets may be due to the nature of the contrast medium, which is a mixture of isomers.

The emulsifying action of body motion on the collection of pantopaque may be responsible for faster absorption in some cases than in others. After a month or two the material becomes fixed in position, which indicates some tissue reaction to the residual pantopaque. None of the patients had any symptoms referable to the residual material.

One patient showed complete absorption of 0.5 c.c. of pantopaque in a period of eleven months.

J. E. WHITELEATHER, M.D.

Variations in Volume and Configuration of the Spinal Canal in Lordosis and Kyphosis; Importance of These Variations for Myelography. Folke Knutsson. Acta radiol. 23: 431–443, Oct. 31, 1942. (In German.)

Both lordosis and kyphosis produce definite changes in the volume and shape of the spinal canal, as can be demonstrated in anatomical dissections as well as by myelography.

In anatomical specimens of the lumbar vertebrae there is generally a narrowing of the spinal canal at the level of the intervertebral spaces, especially in the region between the 4th and 5th lumbar vertebrae and between the 5th lumbar and 1st sacral vertebrae. This narrowing is caused by increased protrusion of the disk and by more marked bulging of the ligamentum flavum. The latter phenomenon is due partly to forward displacement of the articular portion and partly to increased thickness of the ligament. In kyphosis the lumen of the spinal canal is enlarged. As far as the shape of the spinal canal is concerned, there is visible a more pronounced convex bulging of the ligamentum flavum in lordosis of the lumbar spine and the distance between disk and ligament decreases in the intervertebral foramen.

By means of myelography, it can be demonstrated that, in lumbar lordosis, the narrowing of the spinal canal is accompanied by a corresponding narrowing of the dural sac. In kyphosis this narrowing is diminished. ERNST A. SCHMIDT, M.D.

Hemangioma of the Cervical Vertebra with Fracture and Myelomalacia. Olav Holta. Acta radiol. 23: 423–430, Oct. 31, 1942. (In English.)

According to Schmorl, Junghanns and others, the pathological study of autopsy material demonstrates the occurrence of hemangioma in the spinal column in about 10 to 12 per cent of all examined cases. Junghanns' series included 409 spines, with 579 hemangiomata. In about two-thirds of these cases, the hematoma was single. The thoracic spine was most often

spine (about 30 per cent); hemangiomas of the cervical and sacral spine were relatively rare (about 5.5 and 4.5 per cent, respectively).

In the majority of the cases, these tumors are small and centrally located. Clinical symptoms do not appear unless the hemangioma reaches the vertebral surface and affects the adjacent parts, especially the spinal medulla. More or less pronounced transverse lesions of the spinal cord may arise from (1) extension of the hemangioma to the spinal canal, (2) compression by thickening of the vertebral body and arches, and (3) compression fractures of the vertebrae. Roentgenologically, vertebral hemangioma shows marked rarefaction of the spongiosa, resulting in the development of a coarse trabecular structure. In the differential diagnosis, other tumors, hyperparathyroidism, leukemia, and lymphogranulomatosis are to be considered. Symptomatic improvement has been reported following radiation therapy. In cases of definite compression symptoms, laminectomy may bring temporary relief.

The author presents a case of hemangioma in the cervical spine. The patient was a 66-year-old man with the history of a moderate trauma to his head, five weeks prior to hospital admission. The x-ray examination revealed a hemangioma in the 4th cervical vertebra combined with compression fracture and compression myelomalacia. The patient grew progressively worse and died within three months.

The importance of the x-ray examination for determining the diagnosis, extent, and prognosis of the lesions is emphasized. ERNST A. SCHMIDT, M.D.

Aseptic Necrosis in the Epiphyses of Digital Phalanges and Metacarpal Bones (Thiemann's Disease; Dietrich's Disease). Sigurd Franck. Acta radiol. **23:** 449–454, Oct. 31, 1942. (In English.)

Aseptic necroses in the digital phalanges and metacarpal bones were first described by Thiemann in 1909. Since that time, numerous authors have reported cases. Franck describes the case of an 18-year-old male with restricted mobility of the fingers and swelling of the interphalangeal joints. The roentgenograms of the right hand showed flattening of the head of the first metacarpal, a small bone defect in the head of the second metacarpal (combined with sclerosis of the surrounding tissue), smaller bone defects in the head of the first phalanx and in the base of the second phalanx, as well as irregularity of the interphalangeal interspaces in the fourth and fifth fingers, with small exostoses. Similar changes were observed in the left hand. The x-ray changes are interpreted as indicative of a terminated growth disturbance (epiphyseal necrosis) in the epiphyses of the digital phalanges combined with slight arthrosis.

The literature on the subject is reviewed, and, in addition to the roentgenologic and clinical aspects, the etiology and pathology of aseptic necrosis are discussed. ERNST A. SCHMIDT, M.D.

March Fractures: A New Concept of Their Etiology and a Logical Method of Treatment. Louis W. Breck and Norman L. Higinbotham. Mil. Surgeon **95:** 313–315, October 1944.

The authors believe that the actual mechanism of march fracture is similar to crystallization of steel under prolonged variable stress with its resultant fracture. It is postulated that minute bending of the metatarsal occurs with each step during a m[illegible] in response to this prolonged intermittent stre[illegible] molecular rearrangement takes place in the cal[illegible] phosphate in the bone which renders it brittle and ca[illegible] it finally to fracture. This theory, although arrive[illegible] independently, is not entirely new, as it has been [illegible]tioned by various European authors.

During the first six months of 1943, 60 cases of [illegible] fracture of the metatarsus were seen by the aut[illegible] Excellent results were obtained in 48 cases, [illegible] results in 5 soldiers with previously symptomatic [illegible] feet, and a questionable result in 1 case. Treat[illegible] consisted in the use of crutches for four weeks, [illegible] complete restriction of weight-bearing.

March Fracture in Industry. James H. Eddy, New Orleans M. & S. J. **97:** 171–173, October 194[illegible]

Three typical cases of march or fatigue fract[illegible] the metatarsals in women employees of a shell-lo[illegible] plant are recorded. Concerning the compensatio[illegible] pects of such injuries the author says: "The probl[illegible] extremely difficult as it does not fulfill the require[illegible] of an accident. In this state (Louisiana), howeve[illegible] compensation act provides for the payment of co[illegible]sation in all injuries received by an 'employee i[illegible] forming services arising out of and incidental t[illegible] employment.' Under this interpretation of the la[illegible] has been advised that these cases be accepted [illegible] the compensation act."

GYNECOLOGY AND OBSTETRICS

Growth and Development of the Pelvis of Indi[illegible] Girls Before, During, and After Puberty. W[illegible] W. Greulich and Herbert Thoms. Yale J. Bio[illegible] Med. **17:** 91–97, October 1944.

To study the changes in the size and shape o[illegible] superior aperture of the female pelvis during pub[illegible] and adolescence, 107 girls, ranging in age from fi[illegible] fifteen years at the inauguration of the study, [illegible] examined at approximately annual intervals ov[illegible] period of four or five years. Ten of the girls [illegible] re-examined six years after the original examina[illegible] On each occasion the girls were weighed and meas[illegible] the degree of development of various secondary se[illegible] characters was recorded, and anteroposterior [illegible] lateral x-ray films of the pelvis and a postero-ant[illegible] film of the hand and wrist were made.

The pelves of the majority of prepuberal girls ([illegible] to four years before menstruation) were found t[illegible] long oval in shape, with a pelvic index greater tha[illegible] *i.e.*, they were dolichopellic, according to Tur[illegible] classification. At this stage the pelvis was chara[illegible]ized by an acetabular constriction, formed by a[illegible]ward projection of the pelvic walls into the pelvic c[illegible] medial to each acetabulum.

During the years just before puberty, the sup[illegible] pelvic aperture grew slowly and symmetrically. [illegible] puberty, the pelvis began to widen more rapidly th[illegible] increased in its anteroposterior diameter, the fore[illegible] widened and became more rounded, and the acetab[illegible] constriction began to disappear. These changes, w[illegible] effect a virtual remolding of the superior pelvic ape[illegible] and the pelvic canal, required about eighteen mo[illegible] for completion. After the remolding of the pelvis [illegible] completed, there was little further increase in size [illegible] practically no change in shape in those girls who [illegible] followed to early adulthood.

The puberal remolding of the pelvis began after the ad" stage of breast development had been attained 1 after some pubic hair had appeared. Axillary r was not usually present until the pelvic remolding l begun. The pelvic changes were always under y before the occurrence of the menarche and the fu- n of the epiphyses of the distal phalanges of the hand. Their constant position in an orderly sequence of oeral changes that are known to be hormonally de- mined suggests a similar endocrine basis for the rapid wth and remolding of the pelvis which occur during oerty.

Eight plates are appended. Each consists of a series ilms of the pelvis of the same girl, made at intervals r a period of years.

THE GENITO-URINARY SYSTEM

njuries of the Urinary Tract Complicating Fractures he Pelvis. T. H. Sweetser. Minnesota Med. 27: -816, October 1944.

Among 103 consecutive cases of proved fracture of pelvis treated in the Minneapolis General Hospital the last five years, gross injury to the urinary tract urred in 12 and there was unexplained hematuria in others. Among the 12 cases of gross injury, were 2 rupture of the bladder, 3 of rupture of the posterior thra, and 2 definite renal injuries.

Diagnosis of urinary tract involvement depends inly on the history and physical findings, supple- nted by intravenous urography or catheterization l cystography with an organic iodide solution, such skiodan, diodrast, or neoiopax. In dealing with re- t trauma, intravenous urography may be employed he blood pressure is high enough to insure good renal put. If results are not satisfactory, a soft rubber heter may be passed (though too much reliance not be placed on the findings) and 2 or 3 ounces of organic iodide solution introduced through this. e use of air or sodium iodide is not recommended. stoscopy is considered too dangerous and would ally be valueless.

njury of the bladder or deep urethra requires early gical treatment to avoid disaster, suprapubic cyst- omy with drainage of the perivesical tissues being the ential feature. Exploratory opening of the peritoneal ity should be a preliminary step in the operation. he patient's condition permits, tears in the bladder uld be sutured or the torn urethra brought into line a catheter passing through the penile urethra or ough a perineal urethrotomy.

Seven case summaries are included and roentgeno- ms are reproduced. PERCY J. DELANO, M.D.

Renal Dystopia Due to Intra-Abdominal Masses, h a Review of the Literature and Report of Five ses. H. R. Fishback, Jr. Am. J. Roentgenol. 52: -528, November 1944.

Of 34 cases of splenomegaly, hepatomegaly, pan- atic tumors, and miscellaneous intra-abdominal sses observed either roentgenologically or at opera- n to see if there was displacement of the kidney, 5, 14 per cent, showed renal dystopia. Two of these es showed displacement of the left kidney by an arged spleen, one by a pancreatic tumor, one by atomegaly, and the fifth by splenomegaly and hep- megaly. Two were demonstrated by retrograde pyelograms, two by flat plates, and one by an intrave- nous pyelogram.

A survey of the literature seems to indicate that, while displacement of the kidney by intra-abdominal masses is not common, it nevertheless does occur. Gloor (Acta. radiol. 15: 467, 1934) explains displace- ment of the kidney by the spleen as due to (1) pressure of the spleen on a floating kidney, thus dislocating the latter downward, or (2) adhesions between the capsules of the kidney and spleen, causing horizontal displace- ment of the kidney toward the mid-line. It is impor- tant to include the possibility of an intra-abdominal mass in the differential diagnosis of renal dystopia.

CLARENCE E. WEAVER, M.D.

Renal Ectopia: Report of 6 Cases. Ormond S. Culp. J. Urol. 52: 420–429, November 1944.

During urologic study of 747 patients, the author found 6 cases of renal ectopia. Three were of the uni- lateral variety; 2 were crossed ectopia with fusion, and 1 crossed ectopia without fusion. All conformed to Daseler and Anson's criteria of renal ectopia: ab- normal blood supply, fixation, malrotation, and short ureter (J. Urol. 49: 789, 1943).

Of the 3 patients with simple unilateral ectopia, one had a staphylococcus infection of the kidney. The other two complained of dull pain on the involved side, but there was no evidence of infection.

In the 2 patients having crossed ectopia with fusion, the ectopic organ was on the left side and below the normally placed kidney. One had nocturnal enuresis without evidence of infection. The other patient passed a urinary calculus before the pyelogram was made, but no other calculi were found.

The patient with crossed ectopia unfused had a hypo- plastic ectopic kidney, and the normally placed organ was enlarged and had a double pelvis and ureter. This patient complained only of nocturnal enuresis.

The author found that filling the pelvis on retro- grade pyelography reproduced the pain in two patients, indicating that symptoms may be present without secondary disease.

In conclusion, it is pointed out that two patients had no symptoms, two had symptoms due to superimposed disease, and two had symptoms which may have been due to the ectopia itself. JOSEPH SELMAN, M.D.

Contribution to the X-Ray Diagnosis of Ectopic Kidney. Gösta Fallenius. Acta radiol. 23: 455–461, Oct. 31, 1942. (In German.)

In all cases of apparent absence of a kidney or of in- conclusive pyelographic findings, the possibility of renal ectopia should be considered. If neither pyelog- raphy nor urography leads to a definite diagnosis, the author's method of simultaneous gas filling of bladder and colon may demonstrate the presence of an ectopic pelvic kidney. A series of 8 cases of pelvic kidney ob- served at Stockholm hospitals is analyzed.

ERNST A. SCHMIDT, M.D.

Long Standing Hydronephrosis with Associated Uro- logical Disease. Case Report. Vincent J. O'Conor. J. Urol. 52: 408–414, November 1944.

The author reports a case of giant hydronephrosis and hydroureter of fifty years' duration, due to con- genital obstruction at the left uretero-vesical junction. In addition, there existed a hypertrop

a diverticulum of the bladder which caused symptoms. A calculus 3 cm. in diameter occupied the lower ureter. The patient withstood prostatectomy, diverticulectomy, and ureteronephrectomy and returned to full-time work at the age of sixty-seven.

EDWIN L. LAME, M.D.

Vesico-Ureteral Reflux. George C. Prather. J. Urol. **52:** 437–447, November 1944.

Majority opinion is that vesico-ureteral reflux in the normal person is exceptional if, indeed, it does exist. After summarizing the literature the author reaches the conclusion that, for reflux to occur, it is necessary to have sustained tonus of bladder musculature as it resists distention, and that the anatomical features of the uretero-vesical junction (principally the length and condition of the intravesical ureter) govern the frequency or incidence of vesico-ureteral regurgitation. The oblique course of the intramural ureter probably provides an additional measure of protection. No sphincter exists at the uretero-vesical junction.

Vesico-ureteral reflux is not uncommon when there is distortion of the uretero-vesical valve (intravesical ureter). Distortion may be caused by an inflammatory process, a malignant neoplasm, or mechanical influence from changes in the bladder, trigone, or bladder neck. There is evidence that an incompetent valve permits direct ascending infection and finally a hydroureter. The cause of the reflux should, therefore, be sought for and remedied.

A case is reported in a soldier with a fracture of the pelvis, incomplete dislocation of the left sacro-iliac joint, intraperitoneal rupture of the bladder, and incomplete rupture of the posterior urethra. Suprapubic cystotomy with splinting of the posterior urethra was performed. After removal of the suprapubic tube, cystoscopy revealed a bladder calculus. A urethrogram nine months after the accident demonstrated an irregular stricture in the posterior urethra and a small bladder with reflux up both moderately dilated ureters. A urogram revealed bilateral pyelectasis. A suprapubic cystolithotomy disclosed an "hourglass" bladder with a transverse fibrous septum on the posterior bladder wall which confined the calculus to the distal or trigonal segment of the bladder. The septum was thought to be a residuum of the previous rupture and closure. It had produced distortion of the ureteric regions and was believed to be a likely factor in causing the reflux. The stone was removed and the septum bisected. Approximately one month later a urethrogram revealed no reflux and another urogram showed remarkable improvement in the pyelectasis. A subsequent urogram was essentially normal.

The author believes that the transverse band and inflammatory changes secondary to cystitis and the stone were contributory factors. The excellent result stimulates interest in the mechanism of vesico-ureteral reflux and the correction of responsible conditions.

CHARLES A. PERRYMAN, M.D.

THE BLOOD VESSELS

Value of Venography in Varicose Veins, with Report of Three Cases. Allison E. Imler, Meredith G. Beaver, and William C. Sheehan. Am. J. Roentgenol. **52:** 514–520, November 1944.

Varicose veins are the most common disorder of the venous circulation of the lower extremity. The obliteration of these superficial channels by various proced[ures] is carried out with the supposition that the deep ve[ins] are patent and will adequately handle all the ve[nous] return. Barrow (Arch. Surg. **45:** 633–646, 1942) stated that practically all cases of asymptomatic [su]perficial varicosities show normal deep and comm[uni]cating veins, while in patients with severe sympt[oms] incompetency of the deep and/or communicating v[eins] is usually present. Varicosities associated with d[eep] venous obstruction or marked stasis of the deep cir[cu]lation are compensatory and will recur following [ob]literation. This small but important group of ca[ses] should be identified by venographic studies and un[nec]essary or improper operative interference preve[nted]. Even in the presence of almost complete stasis of t[he] deep veins, patency tests may indicate an adequate [cir]culation.

A 35 per cent solution of diodrast is the most co[m]monly used contrast medium. A sensitivity test sh[ould] be done to avoid serious sequelae. The authors r[eport] three cases in which venograms demonstrated co[ndi]tions which contraindicated operative interference [for] superficial varicosities. In one there were dilatations [and] stasis in the distal portions of the tibial veins. In [an]other there was congenital atresia of the right exte[rnal] iliac vein, with an anomalous long saphenous v[ein] carrying most of the venous return from the right lo[wer] extremity across the abdomen to pass through the l[eft] external iliac vein. In the third patient the correla[tion] of the history and the roentgen findings resulted i[n a] diagnosis of healed thrombophlebitis of the left su[per]ficial femoral vein, producing a complete obstructio[n of] this vein.

CLARENCE E. WEAVER, M.D.

The Roentgenogram in Floating Thrombus. G[östa] Fallenius. Acta radiol. **23:** 444–448, Oct. 31, 19[42]. (In German.)

Phlebography by means of perabrodil, which [has] become a routine method in varicosities of the lo[wer] extremities has in late years been extended to the [di]agnosis of thrombosis. Due to the high specific gra[vity] of the contrast medium, better roentgenograms [are] obtained in vertical position of the leg than in [hori]zontal position.

The phlebographic picture of thrombosis varies [ac]cording to localization and extent of the lesion. Ro[ent]genologically, deficiency or irregularity of contr[ast] filling in a smaller or larger part of the venous circ[ula]tion suggests the diagnosis, which may be further co[n]firmed by the demonstration of collateral circulati[on]. If this collateral circulation is absent or little develop[ed], the thrombosis is probably recent; the presence of [w]ell developed collateral veins points to post-thromb[otic] changes. Marginal thrombi may be old; float[ing] thrombi must be of recent origin. In the venous p[at]tern the floating thrombus is characterized in the roe[nt]genogram by a filling defect which is seen free but par[tly] surrounded by a thin layer of radiopaque substance, [in] the lumen of the vein. The diagnosis of floating thro[m]bus is very important in view of the danger of embol[ism].

ERNST A. SCHMIDT, M.D.

Aneurysm of the Anterior Tibial Artery. With Note on Arteriography. Martin Fallon. Lancet [2:] 270–272, Aug. 26, 1944.

In open wounds the amount of damage to vasc[ular] structures can be estimated and the appropriate tre[atment]

ient carried out at the primary operation. Serious ascular lesions resulting from slight penetrating or erforating wounds of the multiple type, so common in nis war, may, on the other hand, conceivably be overooked. In some cases, the initial vascular injury may e limited to a slight contusion or even a small tear of ne vessel, both of which may resolve. In others, the endency is for the effects of the injury to progress, and ne vessel either ruptures spontaneously into the tissues r an aneurysmal sac slowly forms, or both.

A case of traumatic aneurysm, which was unsusected until some months after the injury, is reported. he patient was wounded by mortar fire on Sept. 5, 943, a small fragment of metal entering the left leg nteriorly about two inches below the tuberosity of the bia. This injury seemed to cause little discomfort, ut there was swelling of the leg. With bed rest, the velling disappeared and the patient was discharged to is unit seven days after his injury. He managed his uties fairly satisfactorily, although his leg became tiff and tense after any exercise, and at times he nought it was weaker. There were no skin changes. On Dec. 19, the leg was very swollen. On Jan. 7, 1944, oentgenography showed a small foreign body lying osterior to the interosseous membrane. At this time here was a gross, uniform swelling of the whole left leg elow the knee. There were no pitting on pressure, no kin changes, and no enlargement of the superficial eins. The movements of the ankle joint were normal ut no tibial pulses could be detected. The limb was levated in bed and after a week the swelling had subided except for a more localized area in the upper part f the leg, which was obviously pulsatile. In front, the rea was circumscribed and appeared subcutaneous at ne point. Behind, it was much less defined and exended over a wide area deep to the calf muscles. A oud systolic bruit synchronous with arterial pulse was eard on auscultation. This disappeared when the emoral artery was compressed in the groin. The osterior tibial pulse was present at the ankle, but the nterior tibial pulse was only just perceptible. Fluoroscopy showed the foreign body lying posterior to the nterosseous membrane and immobile. The aneurysmal ac was obviously continuous through the interosseous nembrane and from its anatomical position could be lerived from either or both tibial arteries.

Arteriography was carried out to determine the exact ize, shape, and anatomical location of the sac. Ioloxyl ("Pyclectan" Glaxo) was the only contrast nedium available. The femoral artery was exposed y a small transverse incision in the groin and 0 c.c. of iodoxyl was injected into the vessel in ten econds, the vessel being compressed above. Films were aken at intervals of two seconds from beginning of the njection, six films in all. There was fairly brisk hemorhage from the puncture site after removal of the needle, ut this was easily controlled by digital pressure and eased entirely after five minutes. It could, however, e a serious complication to a blind puncture of the essel.

The third arteriogram in the series, taken six seconds rom the start of the injection, shows the outline of the opliteal artery and the beginning of the anterior tibial rtery with articular branches to the knee. The aneurysnal sac is clearly shown and it is constant for the vhole series. It is roughly circular in outline, with a niche on its distal border corresponding to the interoseous membrane, and has a prominence anteriorly which overlaps the shadow of the anterior tibial artery. The anterior tibial artery distal to the aneurysm was much wider than the proximal, which may be attributed to the damage to the periarterial sympathetic nerves at the point of rupture of the vessel. The posterior tibial artery was clearly outlined, though much less dense than the first part of the anterior tibial artery, and obviously displaced posteriorly by the aneurysm. The last arteriogram of the series, taken 12 seconds from the beginning of the injection, showed in addition to the sac the small saphenous vein to be the only vessel well filled. The whole of the calf was covered by a complicated network of venous shadows, both superficial and deep, which obscured the arterial shadows.

Operation was performed a week following arteriography and the patient made an uneventful recovery.

Complications Following Arteriography of Peripheral Vessels. Frederick B. Wagner, Jr. J. A. M. A. **125:** 958–961, Aug. 5, 1944.

The author calls attention to the growing importance of arteriography in the more accurate diagnosis of arterial lesions, especially of the extremities, and the earlier diagnosis of bone tumors. At the same time, he points out that this procedure is not without danger. Local and systemic reactions may occur, with both mechanical and chemical factors playing a part in their etiology. A case report illustrates a local complication and the various other local and systemic reactions are discussed. The local reactions consist of hematoma, extravasations, and severe vasospasm lasting several days, the last being usually incident to the use of organic iodine contrast material. Systemic reactions may occur following the introduction of either thorotrast or organic iodides, consisting usually of erythematous eruptions and the picture of vasomotor collapse, subsiding after a short interval. Severe liver disease, nephritis, and uremia are the main contraindications to the use of contrast media. The author believes these dangers may be minimized by proper selection of cases, a wise choice of contrast material, testing for sensitivity to the medium to be used, painstaking technic, and preparedness for prompt treatment.

GUERDON D. GREENWAY, M.D.
(University of Michigan)

ENDOCRINOLOGY

Endocrinology: A Synopsis of Normal and Pathologic Physiology, Diagnostic Procedures, and Therapy. Edward C. Reifenstein, Jr. M. Clin. North America 28: 1232–1276, September 1944.

In a comprehensive discussion of endocrinologic physiology, diagnosis, and treatment, the author lists roentgen studies which are of aid in the diagnosis of endocrine disease:

X-Ray Examination of the Skeleton. Bone age is delayed in panhypopituitarism, other cases of pituitary underfunction, hypothyroidism, and hypogonadism; it is increased in precocious puberty.

Wide thoracic vertebrae are seen in acromegaly; crushed, wedged, or "codfish" vertebrae in postmenopausal or senile osteoporosis or the osteoporosis associated with Cushing's syndrome; vertebral "epiphysitis" in long-standing gonadal deficiency; increased density in metastases from carcinoma of the prostate, sometimes simulating Paget's disease.

Roentgenograms of the long bones, jaws, ribs, and pelvis may show cysts and "brown" tumors in hyperparathyroidism; increased density of bones in hypoparathyroidism; metastases from carcinoma of the prostate.

Terminal tufting of the phalanges is found in acromegaly.

Skull plates show sella turcica changes in the presence of pituitary tumors; calcification in suprasellar cysts; osteoporosis in Cushing's syndrome; decalcification in hyperparathyroidism; calcification of the choroid plexus and density of bone in hypoparathyroidism.

Dental films may reveal an absence of the lamina dura in hyperparathyroidism; "blunted roots" in hypoparathyroidism.

Examination of the Genito-Urinary Tract. A flat plate of the abdomen may show renal calculi in hyperparathyroidism, Cushing's syndrome, and osteoporosis; displacement of the kidney with adrenal tumor or hyperplasia; decreased density of the bony pelvis in osteoporosis; increased density with metastases from carcinoma of the prostate. An intravenous pyelogram will reveal displacement of the kidney by adrenal tumor or hyperplasia. Displacement of the kidney and adrenal enlargement may also be demonstrated with the aid of perirenal air injection.

Roentgen examination of the chest and of the esophagus after barium may disclose a mediastinal thyroid or parathyroid tumor

A bibliography of fifty-two references covering various phases of endocrinology is appended.

FOREIGN BODIES

Modern Achievements of Roentgenology in the Problem of Residual Projectiles, with Special Reference to the "Boloscope." G. J. van der Plaats. Acta radiol. 23: 511–532, Oct. 31, 1942. (In German.)

Van der Plaats discusses the different roentgenological methods used for the detection and localization of projectiles (bullets, bomb and shell splinters, etc.) within the human body. The procedures are divided into those before operation (fluoroscopy, aimed radiography, stereoscopy) and those applicable during operation (fluoroscopy, radiography, "boloscopy"). The advantages and disadvantages of all these methods from the point of view of both radiologist and surgeon, are treated in detail and illustrated by roentgenograms and case histories.

A considerable portion of the article deals with a localizing instrument developed by the Philips-Metallix Co. of Einthoven and sold under the trade name of "Boloskop" (boloscope). The procedure utilizes light beams at different angles analogous and simultaneous with two x-ray beams, directed toward the radiopaque foreign body. The lateral and vertical adjustments, requiring but a few seconds, are done by means of fluoroscopy and controlled by a small "cryptoscope." From the position of the light beam, its distance from the body surface, and relation to the operative wound, the location and depth of the foreign body can be directly ascertained. The light beam guides the hand of the surgeon, while the necessary manipulation and eventual readjustments of the boloscope during the operation are left entirely to the roentgenologic personnel. The danger of x-ray burns is minimized in competent hands.

A detailed description of the apparatus is lacking; the reader is, in this respect, referred to previous publications. Since all the references are to the European medical literature, it may be well to mention some of these articles which, in addition to pamphlets of the Philips-Metallix Co., should be easily available in this country: Fesenmeyer, F.: Zentralbl. f. Chir. 68: 78, 1941; Oberdalhoff: München. med. Wchnschr. 8 353, 1941; van der Plaats, G. J.: Fortschr. a. d. Geb. d. Röntgenstrahlen 63: 167, 1941; Schlaaff, I.: Zentralbl. f. Chir. 67: 1924, 1940. ERNST A. SCHMIDT, M.D.

RADIOTHERAPY

NEOPLASMS

Tragedy of Malignant Melanoma. Margaret C. Tod. Lancet 2: 532–534, Oct. 21, 1944.

Miss Tod discusses 100 cases of melanoma from the records of the Holt Radium Institute, Manchester, England, of which she is Assistant Director. She explains that the material is not sufficient for statistical study; nevertheless, the report is of interest inasmuch as out of 100 patients, 50 are still alive, and 8 have been cured for over five years. Seventy-three per cent of those treated early and by radical surgery were alive over various periods of time, an excellent result.

From her experience on this material the author believes that removal, for cosmetic reasons only, of pigmented moles which have long been present but are not growing is inadvisable, unless the victim is willing to undergo radical surgical treatment. Halfway measures have been amply demonstrated to be not only useless but highly dangerous to the life of the unfortunate person who allows an incompetent to treat an apparently benign lesion. If the patient has a pigmented nodule which has begun to grow, radical surgery should be done immediately. Most of these pigmented tumors are highly resistant to radiation, though as a last resort, if the patient is inoperable, radiotherapy may be tried. If regional nodes are invaded, the only possible benefit is from wide removal of the primary growth and the nodes. In such instances, a few cures may be expected. If metastases are widely distributed, no cure by any treatment is probable, but some palliation has on occasion been obtained by heavy irradiation.

Some criticism is made, in the paper, of the general practitioner who treats moles by various home remedies, coagulation, caustics, etc. To anyone who has experience of the worthlessness of such methods this criticism is mild and entirely justified. It called forth, however, several letters (printed in subsequent issues of the *Lancet*) in which Miss Tod is criticized for "betraying" the profession. But how about betraying the patients for whose care one is legally and morally responsible? There is also in these letters some criticism of a few photographs which illustrate late extensions, but these are quite innocuous for a medical journal. Only one letter, that of Hodson (Lancet 2: 769, Dec. 9, 1944), praises Miss Tod's article as it deserves. As a matter of fact, the criticisms made in the others are mostly beside the point, as anyone who sees a large number of these patients improperly treated knows only too well. FRANCIS CARTER WOOD, M.D.

Cancer of the Tongue: Its Diagnosis and Treatment. Louis H. Jorstad and D. J. Verda. Surg. Clin. N. A. 24: 1077–1088, October 1944.

A comparison of a series of patients at the Barnard Free Skin and Cancer Hospital, St. Louis, with a private group emphasizes the importance of an early diagnosis of cancer of the tongue. Not only is the prognosis more hopeful if the lesion is controlled in the early stages of its growth, but metastasis is less likely to occur in the secondary (metastatic) zone of lymphatics. In the private series, with a greater percentage of early cases, 70 per cent of the patients showed no evidence of metastasis five to ten years following treatment of the local lesion; in the Barnard group, the corresponding figure was 45 per cent.

An early lingual cancer is one of a few weeks' duration, not over 2 cm. in its greatest dimension, and with no lymph nodes palpable in the drainage zone. The appearance of the primary lesion is usually that of an ulcer with an irregular border. The edges and base of the lesion are woody and hard in consistency. Necrosis, usually absent in the small lesion, becomes a more prominent feature as the neoplasm increases in size. The histologic grade of malignancy is of significance in estimating the prognosis and in certain cases is of value in planning treatment. Cancer of the tongue must be differentiated from syphilis and tuberculosis. A diagnosis of syphilis cannot be based solely upon a positive serological test; a careful history, observation of the lesion under antisyphilitic therapy, and biopsy are essential. Four per cent of the patients in the private series and 12 per cent of those in the Barnard group, with cancer of the tongue, had syphilis also.

Surgery has proved disappointing in eradicating carcinoma of the tongue. Removal of half or all of the tongue produces a "social outcast," as it is extremely difficult for the patient to speak with any degree of clarity after these procedures. Furthermore, the postoperative mortality is prohibitive, particularly in view of the likelihood of recurrence in those who survive operation. The high death rate following the combined operation of resection of half of the tongue plus deep neck dissection contrasts unfavorably with that attending radon implantation into the tongue plus deep neck dissection. In the authors' experience, radium emanation in the form of the "gold seed" or "gold radon implant" has been found more satisfactory in treatment of cancer of the tongue than radium and removable radium needles, and the 1.5-millicurie seed superior to the 1-millicurie glass or gold radon seed. The seeds are implanted, under general anesthesia, 1 cm. apart, around and into the lesion if necessary. Sixty-four per cent of the Barnard series and 90 per cent of the private series showed no evidence of local recurrence or incomplete regression of the cancer following radon implantation.

Local reaction from the radon begins within forty-eight to seventy-two hours and reaches its maximum within two to four weeks. During this period there is considerable discomfort due to swelling and salivation. At the end of two months, a soft, pliable, smooth area should have resulted. In some cases, particularly if the lesion is large and involves the floor of the mouth, it will require one or two months more for the central area of necrosis to separate and fill in with granulation and scar tissue. Persistent induration, particularly if distributed irregularly, is indicative of recurrence.

Surgical resection of the lymph-bearing tissue in the secondary drainage zone (neck dissection) is the treatment of choice in controlling metastasis. In cases with inoperable cervical metastases, distant metastases, or a primary lesion involving contiguous structures, cautery or diathermic removal of necrotic masses or dead bone, alcohol injection or surgical section of nerve trunks, section of sensory roots, interstitial and roentgen irradiation within tissue tolerance are of palliative value, alone or in combination.

Primary Carcinoma of the Trachea. Treatment with Intratracheal Radium; Radioactive Iodine Fails to Show Thyroid Origin. Philip H. Pierson. J. A. M. A. **126**: 206–209, Sept. 23, 1944.

In a 61-year-old male with a three-year history of periodic attacks of cough and sputum (frequently bloody), progressing to wheezing, dyspnea, hemoptysis and reduction of the voice to a whisper, bronchoscopy revealed a tumor involving the anterior tracheal wall above the carina. Biopsies were interpreted as showing low-grade, well differentiated primary adenocarcinoma of the trachea. Tumor tissue removed two days after the ingestion of radioactive iodine exhibited no radioactivity, ruling out the presence of normal thyroid tissue but not necessarily excluding carcinoma of the thyroid. Endoscopic removal of tumor tissue was carried out in multiple sessions followed by radium irradiation by means of an ingenious, specially devised intratracheal applicator. Examination two years after treatment showed the patient to be in good health without evidence of recurrence. A review of the literature by the author emphasizes the infrequent occurrence of the lesion and discloses that resection of a portion of the tracheal wall has been done with varying success, and that intratracheal operations as well as radiation methods employed in the past have generally given poor results.

ISADORE LAMPE, M.D.
(University of Michigan)

Radiation Therapy of Carcinoma of the Breast. M. V. Peters. Canad. M. A. J. **51**: 335–343, October 1944.

The author presents a review of the more striking features of irradiation of mammary cancer. Three main groups present themselves for treatment (Steinthal's classification).

In Stage I the growth is limited entirely to the breast, with no fixation. These cases are further subdivided into (*a*) those with a low index of malignancy and (*b*) very early lesions in which differential diagnosis is impossible clinically. Fifty to 75 per cent of this group will be cured by radical amputation.

Stage II includes cases in which the tumor is fixed to the skin or there is axillary involvement. This group is considered moderately malignant. Twenty to 25 per cent will be cured by radical amputation or will be free from recurrence for five years or more. Postoperative radiation should be well worth while in this group. Of 297 cases reported from the Presbyterian Hospital, New York (Haagensen and Stout), approximately one-half received postoperative prophylactic radiation, with a five-year clinical cure rate of 31.5 per cent, compared with 24.7 per cent for the group not receiving postoperative radiation. Preoperative irradiation is believed to be of even more value, as it may cause partial or total regression of the tumor or the involved nodes, if they are radiosensitive, and render the tumor more defined and freely movable.

Stage III cases are those with more than axillary lymphatic involvement, ulceration, or adherence to the deep tissues. There are three subdivisions: (*a*) carcinoma arising during lactation, (*b*) very malignant types, and (*c*) a less malignant group with extensive spread locally by metastasis. Subgroups *a* and *b* will resist any known form of treatment, even if applied as soon as the lesion is discovered. In this group, the best results are obtained by applying radiation primarily, provided x-ray equipment of sufficient voltage capacity is available under the direction of a competent radiologist. After intensive irradiation of the primary and secondary lesions, a certain percentage of these cases become operable.

For Stage I tumors three series of postoperative irradiation are given, each lasting one week, the first series being started as soon as the incision has healed. The second series is given one month later, and the third three months later. The factors are 200 kv., 0.5 mm. Cu, and 50 cm. distance; 600 r are given to the neck and to the axilla from each of two directions; 1,800 r to the chest wall tangentially in small fractionated doses. Stage II tumors are treated postoperatively in the same way, with additional radiation to the node-bearing regions, 400 kv. being used for two of the three series. The axillary and supraclavicular regions receive 1,800 r over a period of two weeks, and the infraclavicular region is included in one of the axillary fields.

Treatment of Stage III growths, as well as preoperative therapy, must take into consideration the size and extent of the lesion, the degree of lymph node involvement, and the presence or absence of metastasis. The degree of skin reaction is used as a guide. This reaches its peak about two weeks after the treatments are completed. The primary lesion is treated with 400 kv., with a portal large enough to include the whole breast but with the primary beam on the tumor itself. Rays are applied in four directions, superior, inferior, mesial, and lateral, cross-firing the breast tissues. The reduction in the size of the mass is carefully observed and a minimal total of radiation is administered to insure complete restoration of tissue substance for the benefit of the surgeon (where operation is contemplated) and still produce the optimum effect upon the tumor. On completion of treatment, the axillary areas are irradiated to reaction but not to the same degree as the primary lesion, unless the nodes are involved. The whole course usually requires six weeks. If mastectomy is indicated, it may be performed as soon as the reaction has completely subsided.

In recurrent carcinoma and cases with distant metastases treatment varies, but the main objective is to relieve unpleasant symptoms and prolong life. Pain is due in a large percentage of cases to skeletal deposits. Many cases respond well to treatment of the bone lesions, especially if they are the first and sole form of recurrence. Recalcification takes place and life is prolonged one to three years before additional metastases appear.

The data presented as to relationships between age and rate of growth, extent of disease, and three-year survival in cases irradiated preoperatively show that the prognosis in many of the earlier cases of carcinoma of the breast could be improved by preoperative radiation in preference to or in conjunction with postoperative radiation. The statistics further show that the prognosis or expected five-year cure rate is approximately 19 per cent better if considerable postoperative radiati[on is] included in the treatment. The survival rate d[ropped] gradually from one to five years in Stage I but sha[rply] in Stage II group around the three-year mark. [As a] rule, the higher the age group, the better the progn[osis], with a difference of only 6 per cent between the extremes of age. From the tables shown, the follo[wing] conclusions are reached: (1) Radiation offers the [only] hope of relief of distressing symptoms in hopeless c[ases] of carcinoma. (2) The most promising group of ca[ses], Stage I, is no doubt benefited by prophylactic radiat[ion], the survey showing the five-year clinical cure rate t[o be] raised from the average of 65 to 75 per cent. (3) In [the] large group of cases between the two extremes, [in] which the clinical factors add up to a high degre[e of] malignancy, statistics show that postoperative ra[dia]tion has raised the survival rate 15 to 20 per cent.

H. T. GUARE, M.D.

Cancer of the Cervix Uteri, 1930–1942. Herbert Schlink and Clement L. Chapman. M. J. Australia [2:] 377–379, Oct. 7, 1944.

This report deals with the results of treatment [of] cancer of the cervix at the Royal Prince Alfred Hosp[ital] (Sydney, Australia) from 1930 to 1942. As the result [of] an agreement made for experimental purposes, t[he] patients were treated by "one full dose of radium, 5,0[00] to 7,000 milligramme-hours, with one millimetre platinum screenage to the uterus and two millimetres platinum screenage to the vagina." After five weeks radical hysterectomy was done in those consider[ed] operable. After five years, the 258 patients studi[ed] showed a survival rate of 29.4 per cent and a cure ra[te] of 28.6 per cent, this group consisting of all those "se[en] with a view to treatment." This rate is compared wi[th] a cure rate of 24.2 per cent of 9,051 patients analyz[ed] by Bourne and Williams, reported from 16 centers r[e]porting to the League of Nations registry. The co[n]clusion is drawn that the form of treatment report[ed] saves 4.4 per cent more patients than radiothera[py] alone.

In 20 per cent of the 112 patients operated upo[n] the lymph nodes were found invaded, and the autho[rs] state that "the majority of radiotherapists admit th[at] treatment by radium or x-rays has no effect on cancer [of] the lymphatic glands." In a later communication [(in] reply to Ham, *vide infra*) the authors give the five-ye[ar] survival rate for the group with lymph node metastas[es] as 29 per cent and the cure rate as 25 per cent.

When the survivals were broken down by the sta[ge] of the disease, the following figures were obtained:

	Cases	Operated	Five-year Survival
Stage I	17	16	82%
Stage II	62	53	56%
Stage III	129	43	19%
Stage IV	50	None	None

Some interesting figures on the ten-year survivals a[re] also cited.

In a letter to the Editor, commenting on this repo[rt], Harold J. Ham (M. J. Australia 2: 441–442, Oct. 2[8,] 1944) points out that, far from justifying the conclus[ion] reached, the survival rate reported has been surpass[ed] in certain well authenticated reports, especially that [of] Regaud, who reported 33 per cent five-year surviv[al]; it is therefore hardly proper to conclude that the meth[od]

ds advocated will save "an additional 4.4 per cent." Vith a statement that absolute statistics are essential o evaluate results of treatment Ham agrees, but points ut that the statistics given are not absolute in that all he patients admitted to the hospital with the diagnosis f cervical cancer are not included. In their finding hat cancer cells still persisted in operated cervices, the uthors failed properly to evaluate the time element, ince regression may extend over two to three months. Since the biological dose is not defined in tissue roentgens, Ham thinks that it is not sufficiently precise for proper research. With the statement that "the maority of radiotherapists admit. . .," etc., cited above, Ham disagrees, since it is at variance with the facts of he response. The authors have abandoned the use of x-ray, yet admit having only a limited experience with t—completely ignoring the great mass of evidence on he subject. Finally, in the analysis of cases in the first hree stages, the relative proportions treated by operaion and radium and by radium alone are ignored, biasng the result. Ham concludes with a plea for "fairninded statistical assessment of all known methods of reatment."

[ABSTRACTORS NOTE: The statistical analysis of Schlink and Chapman is indeed pitiful, as Ham points out. No attempt to compare the cure rates of the individual stages with the League of Nations material is made, although the source material in Heyman's reports gives this information in full. In fact, the authors could profit by a study of Heyman's methods of presenting the results of the reporting centers in the Annual Summaries. Furthermore, even assuming that proper sampling methods had been used, comparable with those of the League centers (Ham points out that this is not so), the difference could easily have arisen through the chances of sampling, since the odds against such an event are only about 6 1/2 to 1. Finally, it is a grave question whether the method of radium therapy used was optimum, and the technical details concerning it are very meager.] LEWIS G. JACOBS, M.D.

Diagnosis and Treatment of Cervical Cancer. Frederick V. Emmert and Harold M. Clarke. Surg. Clin. North America 24: 1185–1197, October 1944.

In a fifteen-year period, 1,000 cases of cancer of the cervix (80 per cent of all admissions to the gynecological service) were seen at the Barnard Free Skin and Cancer Hospital, St. Louis. Six per cent of the patients were between the ages of 20 and 30, 20 per cent between 30 and 40, 31 per cent between 40 and 50, 28 per cent between 50 and 60, 11 per cent between 60 and 70, and 3 per cent over the age of 70 years. Fifteen per cent of the women were nulliparous. In only 2 cases did the cervical carcinoma occur during pregnancy.

Every woman admitted to the gynecological service s examined with a vaginal speculum, and a biopsy specimen is taken of all suspicious erosions of the cervix. This procedure is preferred to cautery conization of the cervix, as the intense heat may destroy early evidence of malignant change. Cancers are graded in accordance with the League of Nations classification. While the immediate mortality following irradiation is considerably less than that following hysterectomy, the late complications leading to death are definitely more frequent. In Stage I cancers, radical surgery in patients who are good operative risks presents definite advantages over irradiation. In Stage II cancers, radical surgery gives too high a prim[illegible] tion of the primary lesion is advisable. It is not certain whether irradiation with removal of the individual iliac nodes will increase the survival rate. In Stage III and IV cancers, irradiation is the only means of treatment.

In all cases in which radiation alone is to be used, a calculated dose of 2,500 r to the site of the tumor is administered. The factors are 200 kv., 18 ma., distance 50 cm., with a Thoraeus filter. In small persons, four ports, two anterior and two posterior, usually suffice, while in extremely large women, six ports, including a perineal port, are sometimes necessary. Treatment is given to two ports daily, 250 r to each. When radical surgery is contemplated, only half the amount of roentgen radiation is employed.

If a patient is considered a poor operative risk, further treatment consists of radium implantation. Under twilight analgesia, the uterus is sounded and the cervical os dilated so that it will accommodate a brass capsule containing, in tandem, three 25-mg. needles in 0.5 mm. of platinum. In the ordinary case two 25-mg. needles in 1 mm. of platinum are imbedded in a piece of sponge rubber (which has been trimmed so that it will fit snugly up against the cervix) in such a manner that one needle will fit into each lateral fornix. An additional 10-mg. needle in 1 mm. of platinum is inserted in the sponge rubber so that it will lie across the area of greatest involvement. The sponge rubber is then placed against the cervix so that the radium is in the desired relation to the surrounding structures. Stout threads are fastened to all radium needles and these threads are tied to a vaginal pack which is inserted over, under, and behind the sponge rubber applicator, increasing the distance of the radium from the bladder, rectum, and vaginal walls, and holding the applicator firmly in place. It is believed that a full dose, between 5,000 and 6,000 mg. hours, well filtered and well distributed, should be given to every patient for whom radium is prescribed.

In surgically treated cases, operation is usually carried out three weeks after the completion of x-ray therapy. Radical abdominal hysterectomy, with removal of the entire uterus, a good portion of the upper vagina, the surrounding connective tissue containing the lymph vessels of the uterus, and at times the regional nodes, is preferred for the early cases of cervical cancer.

Discussion on the Radiotherapy of Malignant Disease of the Ovary. Alan Brews, Margaret C. Tod, and Frank Ellis. Proc. Roy. Soc. Med. 37: 720–730, October 1944.

This discussion was opened by Brews with a general consideration of malignant ovarian tumors and the reported results of surgical treatment. Miss Tod followed with an outline of the radiotherapeutic technic used in the Holt Radium Institute (Manchester), and Ellis contributed figures from the Sheffield Radium Centre.

At the Holt Radium Institute, radiotherapy is given only when the tumor has been incompletely removed or is inoperable. Prophylactic irradiation following complete surgical removal is not considered of value. Treatment is primarily by x-ray, but radium is regarded as a useful adjunct when the uterus is secondarily involved or when the vaginal vault is invaded after hysterectomy. The tendency in treatment has been toward larger fields and higher dosage. Thus, the old technic of using four 10 × 15-cm. fields about the pelvis has been discarded and a new plan evol[illegible]

tute was devised three years ago and utilizes a simple device called a "trunk bridge." Treatment is given to three portals, a direct posterior 30-cm. circular field and two oblique 20 × 30-cm. anterior fields. The "bridge," used to determine the anterior ports, consists of a large baseboard on which the patient lies and is centered. At the side is a post holding a marker set at a 30 degree angle, adjustable as to length. Bolus bags are placed between the skin and the marker to ensure full scattering, and the tube, at a 60 cm. F.S.D., is set to the 30 degree marker. Treatment is given to all three fields daily, starting with 40 r per port and increasing until 100 r is reached. A total tumor dose of 3,000 r can usually be given in three or four weeks. Since large areas are treated by this method, not only must the local skin reaction be watched but the systemic reaction of the patient as well. Generally, a fall in lymphocytes to 300 per c.c. is a danger signal even if the white count is a little below normal, as the latter may drop suddenly with continuation of treatment.

An attempt has been made to establish a relationship between the change in the white blood cell count and the total amount of x-ray absorbed, with the aid of Mayneord's simplest formula for calculating the integral dose. Estimating a 10 per cent loss in the scattering material used in packing the "bridge" and an additional 5 per cent for side packing for narrow patients, the average integral dose delivered in twenty-one to twenty-four days is 48 megagram roentgens. Graphs were made plotting the white counts of 34 patients against the integral dose. The count dropped to 2,500 per c.c. in fourteen days after 20 megagram roentgens had been delivered, at which level it remained fairly stationary, until treatment ceased, when it began to rise. The fall in the total white cell count was paralleled by a drop in lymphocytes to 300 c.c. Although the number of patients treated is insufficient to warrant conclusions, the author's observations here and in a series of seminomas of the testis indicate that a 3,000 r tumor dose can be given safely to the abdomen with the above technic. Further investigation is desired to determine if smaller doses over a longer period of time but with a greater total dose are preferable. A shorter treatment period is considered not feasible because of the necessity of using small initial doses.

Miss Tod's statistics are, according to her own statement, not such as to permit conclusions. Of her most recent series of patients, 26 treated in 1941 and 1942, 13 were alive after one to two years, and this she states represents "not merely a survival of women whose disease has been temporarily arrested, but 92 per cent of all those alive are free from symptoms."

The results reported by Ellis from the Sheffield Centre are based on 105 cases of ovarian carcinoma treated from 1932 to 1939. The series included both recurrences after operation and operated cases without recurrence. Of the total number 25 per cent were alive ("when traced"). To assess the value of radiotherapy, only the cases with definite recurrences or residual growth are considered. Of 68 such patients, 44 per cent survived more than a year, while of 20 untreated patients only 25 per cent were alive after a year. The corresponding figures for three-year survival are 22 per cent and 5 per cent.

The prognosis proved to be more favorable in pseudomucinous cysts than in papillary adenocarcinomas and in unilateral than in bilateral tumors. A combination of x-rays and radium appeared to give better results than the use of x-rays alone. The survival period seemed to improve as dosage was increased, but the figures on this point are admittedly not significant statistically. LESTER M. J. FREEDMAN, M.D.

Malignant Lymphomas of the Spinal Epidural Space. D. J. Verda. Surg. Clin. North America. 24: 1229-1244, October 1944.

Malignant lymphomas may arise in the epidural space itself or may reach that space secondarily, by migration from near-by regional lymph nodes. A case of each type is presented. The symptomatology of malignant spinal epidural lymphomas does not differ essentially from that of other cord tumors; the neurologic findings are similar to those of other epidural tumors.

Dyke divided the roentgen criteria for diagnosis and localization into two classes—in the major class, bone destruction, appearance of the pedicles and evaluation of interpediculate distance, and distortion of the paraspinal tissues; in the minor class, bone proliferation, abnormalities of the intervertebral disks, kyphosis and scoliosis, and calcification. About 80 per cent of the epidural spinal cord tumors are demonstrable by the simpler roentgenographic methods. The most reliable procedure for the localization and investigation of cord tumors is myelography, either with air or lipiodol.

Even though it proves impossible to remove the tumors themselves, laminectomy may relieve the pressure on the cord. In a surgical consideration of spinal epidural lymphomas, the cases should be segregated into two main groups, those in which neurological symptoms are an initial manifestation, prior to any recognizable lymphadenopathy, and those in which spinal cord compression is a terminal manifestation. In the first group, laminectomy should be performed as soon as the level of the tumor can be accurately established. In the second group, surgery is not indicated until roentgen therapy has been given a thorough trial.

One week following laminectomy, in the patients with primary neurologic symptoms, roentgen irradiation to the region of the vertebra where the tumor was located is begun. Preferably, right and left oblique ports are used, directly over the operative site, with the following factors: 200 kv.p., 18 ma., 50 cm. F.S.D., filtration 0.5 mm. Cu, intensity 85 r (with back-scatter 20 × 20 cm.) per minute, the port size depending upon the size of the tumor and area to be treated and the degree of epidural involvement. The daily dosage is 100 r to alternate ports until a total tumor dose of 900 or 1,000 r is reached. In some cases subsequent courses of roentgen therapy are necessary. In the patients with lymphomatous involvement prior to neurologic symptoms, roentgen irradiation is routinely administered to the primarily involved regions. The technic for irradiation of the vertebral area is similar to that above except that, as a rule, larger parts are covered to irradiate all of the affected mediastinal or lumbar nodes. If a plaster body cast is necessary because of vertebral destruction with malalignment of the spinal column, a posterior window may be cut over the area to be irradiated.

Adequate X-Ray and Radium Dosage. Edwin C. Ernst. Surg. Clin. North America 24: 1003-1021, October 1944.

It has not been fully appreciated or realized that roentgen and radium rays possess powers of producing, directly or indirectly, varying degrees of physical, chemical, and biological change. The same type of

cancer may react differently to the same form of radiation in various persons. Again, roentgen or radium rays may inhibit or destroy in a dual capacity the living tissues, depending upon the timing and manner of irradiation. The reactions which tissues show to irradiation and the degree of cell sensitivity to like roentgen dosage may also differ. Similarly, the latent periods of different cell structures vary with different tissues. In some the "time" interval between irradiation and the resulting physical reaction is relatively short, while in others it is more prolonged, even though the type, quantity, and method of administering the radiations are identical. Usually, large amounts of radiation applied in a short time prove less effective than smaller divided doses of equal intensity applied over a longer period.

The successful treatment of cancer is not solely dependent upon elaborate surgical, roentgen, or radium equipment, but equally upon clinical experience, radiation judgment, and the cooperation of physicians in the various fields of medicine.

The author discusses specifically cancer of the breast, cancer of the skin, cancer of the larynx, pharynx, and tonsils, and cancer of the cervix. Cervical cancer demands a greater number of complex combinations of x-ray and radium technics than any other single cancer. Its effective treatment is largely dependent upon the homogeneous distribution, proper timing, and coordination of the roentgen and radium treatments. The importance of recording essential physical and technical radiation factors is emphasized. The treatment record should include not only the air or surface dose in roentgens, the quality of the rays, half-value layer, and daily and total dose delivered to each portal, but also, more particularly in the case of abdominal neoplasms, the size of the patient, since this indirectly predetermines the amount of effective radiation reaching the tumor.

NON-NEOPLASTIC DISEASES

Discussion on Radiotherapy in Chronic Inflammatory Conditions with Special Reference to Mycotic Infections. Alexander B. MacGregor, John Blewett, I. G. Williams, and Finzi. Proc. Roy. Soc. Med. **37**: 717–719, October 1944.

MacGregor's part in this discussion, which is published in abridged form, is concerned solely with actinomycosis. He is said to have advocated a combination of radiotherapy, surgery, and chemotherapy, but no details are given.

Blewett found roentgen therapy of value in superficial infections of the skin and subcutaneous tissues (as furunculosis), osteomyelitis, chronic mastitis, tuberculous adenitis, some cases of chronic arthritis, and early ankylosing spondylitis, as well as in mycotic infections. Of these last, he had a series of 58 cases, of which 55 were proved actinomycosis, 1 blastomycosis, and 2 unproved. Of the 55 proved cases of actinomycosis, 39 were of the cervicofacial and 16 of the abdominal type. The period of observation ranged from six months to ten years. Of 29 patients with cervicofacial actinomycosis receiving radiation therapy, often following failure of other methods, 25 were free of disease; there was a single relapse requiring subsequent surgery, and in the 3 remaining cases no follow-up was obtained. Of 10 patients receiving no x-ray therapy, 6 were known to be free from the disease and no records were obtainable for the other 4. Poorer results were obtained in the 16 cases of abdominal acti[illegible] Of 9 patients treated without x-ray, 5 remained free of disease, 1 was improved, 2 died, and in 1 no follow-up was obtainable. Of 7 patients treated by x-rays, 1 was free of the disease, 4 had died, 1 was still under treatment, and 1 was untraced.

A dose of 300 r was repeated at three-week intervals until all induration disappeared. More intensive treatment induced skin damage and abscess formation. The average required three months.

Williams reported that potassium iodide was still believed to be of value in the treatment of actinomycosis at the Middlesex Hospital. Radiotherapy, however, he designated as "the most useful single therapeutic measure available today," roentgen irradiation being considered simpler and more efficacious than radium. The best results were obtained using a hard ray, 1.3 mm. Cu h.v.l., and fractionated dosage. Daily doses of 100 to 150 r (w.b.s.) were given for a total of about 2,500 r over fields sufficient to cover the entire area involved.

Of 43 patients, 26 had cervicofacial involvement, 12 had the disease in the right iliac fossa, 2 had pleuropulmonary lesions, and in the remainder other sites were involved. The ages ranged from twelve years to sixty-five years and in only 14 per cent was there a history of association with animals or agriculture. There were 6 deaths; none of these was in the cervicofacial group.

Finzi closed the discussion, stating a preference for small doses of radiation for both actinomycosis and tuberculosis, 50 to 60 r, as better results are obtained without danger of skin changes. For actinomycosis he believes that radium gives better results than x-rays "if one can get an adequate dose to the deepest part of the disease without giving the skin a big dose."

LESTER M. J. FREEDMAN, M.D.

Radiation Treatment of Ganglia of the Wrist. Robert J. Reeves. South M. J. **37**: 584–586, October 1944.

Fifteen cases of ganglia of the wrist were treated by roentgen irradiation by the author and followed for more than one year. In 87 per cent of these cases, the lesion cleared up with no skin damage or deformity. The method of treatment was as follows: The ganglion, if more than 1 cm. in diameter, was aspirated and then given 400 or 500 r at 200 kv. with 0.5 mm. Cu filter, half-value layer 1.1 mm. Cu. If the tumor persisted, monthly treatments were given, with three treatments as the average. The action of the x-rays is one of counterirritation with resulting fibrosis and destruction of the endothelial secreting cells. The cosmetic results are better with roentgen therapy than with surgery and no hospitalization is required.

RADIATION EFFECTS

Irradiation Pneumonitis. Report of a Case. Theodore O. Alexander. Bull. Johns Hopkins Hosp. **75**: 199–208, October 1944.

A case of Hodgkin's disease receiving roentgen therapy is described. It is of interest because of the development of severe respiratory symptoms shortly after a course of irradiation to the mediastinum, where the adjacent lung tissues necessarily were not shielded. Roentgenograms showed an extensive pneumonitis. In the nine months from the [illegible]

tute was devised three years ago and utilizes a simple device called a "trunk bridge." Treatment is given to three portals, a direct posterior 30-cm. circular field and two oblique 20 × 30-cm. anterior fields. The "bridge," used to determine the anterior ports, consists of a large baseboard on which the patient lies and is centered. At the side is a post holding a marker set at a 30 degree angle, adjustable as to length. Bolus bags are placed between the skin and the marker to ensure full scattering, and the tube, at a 60 cm. F.S.D., is set to the 30 degree marker. Treatment is given to all three fields daily, starting with 40 r per port and increasing until 100 r is reached. A total tumor dose of 3,000 r can usually be given in three or four weeks. Since large areas are treated by this method, not only must the local skin reaction be watched but the systemic reaction of the patient as well. Generally, a fall in lymphocytes to 300 per c.c. is a danger signal even if the white count is a little below normal, as the latter may drop suddenly with continuation of treatment.

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LESTER M. J. FREEDMAN, M.D.

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had received a total of 6,776 r to the mediastinum. At autopsy, the lungs showed lesions similar to those which have been produced experimentally by over-irradiation. A patchy exudate composed of edema fluid, a few red and white cells, fibrin, and fibrinous-hyaline membrane was found involving the greater portion of each lung. There was widespread organization of this exudate. A few microscopic foci of Hodgkin's tissues were found in the bronchial lymph nodes and in the pericardium. There was no Hodgkin's tissue in the lungs.

Hematologic Complications of Therapy with Radioactive Phosphorus. Louis H. Hempelmann, Jr., Edward H. Reinhard, Carl V. Moore, Olga S. Bierbaum, and Sherwood Moore. J. Lab. & Clin. Med. 29: 1020–1041, October 1944.

The authors' observations are based on 100 patients treated with radioactive phosphorus at the Washington University School of Medicine, and followed for a sufficient period of time to permit evaluation of results. They believe that this form of therapy induces excellent remissions in patients with polycythemia vera, chronic myelogenous leukemia, and chronic lymphatic leukemia. In this series of cases an attempt was made to bring the blood count of the patients with leukemia to normal levels, rather than to treat symptomatically, as most investigators prefer.

In 44 of the 100 patients, a thrombocytopenia of less than 100,000 per cubic millimeter developed (in 33 of these the platelet count was less than 50,000); 41 showed a leukopenia of less than 3,000; and in 36 the red blood cells fell by more than 1 million to a level of under 3.5 million. The authors warn that these hematologic complications may be delayed weeks or months after the last dose of radioactive phosphorus has been given, and because of the variation in susceptibility to the effects of this form of radiation therapy, dosage regulation must be individualized to a high degree.

ELLWOOD W. GODFREY, M.D.

X-Ray Exposure in Manufacture and Operation of Certain Electronic Tubes. A. F. Bush, H. T. Castberg, and D. G. Macpherson. Public Health Rep. 59: 1045–1047, Aug. 11, 1944.

The authors call attention to a possible hazard in the manufacture and operation of high-vacuum electronic tubes. In their investigation they found that during the manufacture, testing, and operation of such tubes, measurable amounts of potentially harmful x-rays were produced. The tubes were tested or operated at voltages above 25 kv. The presence of x-rays was detected with fluoroscopic screens and measured by means of the Victoreen minometer and dental x-ray films. In one industrial situation studied extensively, the exposure of operators was found to be as high as 2.5 r per day (provisional tolerance dose 0.1 r per day, according to National Bureau of Standards). Once this hazard was recognized, it was possible to reduce the intensities below the provisional tolerance dose by the use of sheet lead, sheet steel, and lead glass.

Effects of Repeated Irradiation of the Gastric Region with Small Doses of Roentgen Rays upon the Stomach and Blood of Dogs. W. C. Hueper and de Carvajal-Forero. Am. J. Roentgenol. 52: 5–534, November 1944.

This study was undertaken to determine the possible action of roentgen therapy upon the erythropoietic activity of the bone marrow and upon the blood through a possible effect upon the production of the so-called "intrinsic factor" of Castle. It was found that roentgen rays given in doses of 15 to 120 r up to a total of 4,5 within twenty-five weeks over the gastric region of the caused only minor anatomic changes in the gastric mucosa and a transitory and moderate anemia of the secondary type, followed by an erythrocytotic phase after the cessation of the actinic treatment. Roentgen rays administered in doses of 300 r, up to a total of 6,0 within four weeks, produced a considerable loss in body weight, a moderate to severe secondary anemia, and perforating gastric ulcers at the end of this period. In neither instance was there evidence of anemia of the pernicious variety, which would have resulted if the treatment given had interfered with the production of the "intrinsic factor" generated by the gastric mucosa according to Castle. The chief cells of the gastric mucosa are, according to the observations made, definitely more sensitive to the action of the roentgen rays than any other cellular element of the gastric mucosa.

The histologic changes found in the organs of the dogs which were treated with larger doses over a shorter period of time are described in detail.

CLARENCE E. WEAVER, M.D.

Radium Metabolism in Rats, and the Production of Osteogenic Sarcoma by Experimental Radium Poisoning. Robley D. Evans, Robert S. Harris, and J. W. Bunker. Am. J. Roentgenol. 52: 353–373, October 1944.

The effect of radium given orally and intradermally to rats is the subject of this report. The oral administration of 25 to 100 micrograms of radium resulted about a year later in a high incidence of primary osteogenic sarcoma, usually in the vertebrae, with metastases to the lungs and other organs. The animals exhibited many of the classical symptoms of radium poisoning seen in human beings. The bones showed hypercalcification at the ends. They were fragile, but fractures healed satisfactorily. At death an average of 3 per cent of the radium administered orally remained in the body, while 50 per cent of that injected intradermally was retained. Studies of the various tissues for radium content showed that the bones had at least 100 times the radium concentration of the richest soft tissue (lung). It was found that the rat could not be used for obtaining an estimate of the toxic dose of radium in man. To produce chronic symptoms similar to those in man, the rat requires some 150 times as much radium per kilogram of body weight and some 250 times the skeletal ratio of radium to calcium. L. W. PAUL, M.D.

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PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

GENERAL INFORMATION

Radiology is entered as second class matter at Syracuse, New York, and Easton, Penna., under the Act of August 24, 1912, and accepted November 24, 1934. Radiology is published by the Radiological Society of North America as its official Journal. Subscription rate $6.00 per annum. Canadian and foreign postage, $1.00 additional. Single copies, 75¢ each. All correspondence relative to business matters connected with the Radiological Society of North America and Radiology, or remittance for non-member subscriptions, should be made payable to the Radiological Society of North America and should be addressed to the Secretary-Treasurer, Donald S. Childs, M.D., 607 Medical Arts Building, Syracuse 2, New York. In requesting change of address, both the old and the new address should be given.

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RADIOLOGY

MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

ol. 45 AUGUST 1945 No. 2

The Roentgen Diagnosis of Pulmonary Infarcts[1]

LT. COL. GEORGE R. KRAUSE, M.C., A.U.S.

THE ROENTGEN diagnosis of a pulmonary infarct is probably subject to a reater percentage of error than that of ny other lesion of the lung. The error s almost always a "negative" one, that is, ailure to suspect an infarct as the cause of he abnormal shadow present on the roentenogram. In its protean manifestations his pathologic process may mimic almost ny other lung disease. This factor and he supposed rarity of the disease probably ccount for the high percentage of "negaive" errors.

This paper is based, in part, on 344 intances of aseptic hemorrhagic infarction f the lungs seen at autopsy in a ten-year eriod (1930–39) at the Cleveland City Iospital. In 174, the infarct was the ma- or cause of death or was an important ontributory factor, but in only 22 per cent as the correct diagnosis made. In 73 ases adequate clinical and/or roentgenogic correlation with the autopsy findings as possible. A study of this series, stressg the clinical aspects, has been reported). In the course of that study, a number patients were seen who recovered from pulmonary infarct, and since that time veral others, including some with various mplications, have also been followed. hese two groups have also been studied in e preparation of this report.

A brief review of the clinical findings will be presented, the roentgen signs will be discussed in detail and illustrated, and the differential diagnosis considered. It is hoped that, in this manner, a clearer concept of the entire picture will be gained and that the number of diagnostic errors will be reduced. If the roentgenologist is able to make a correct diagnosis of an infarct of the lung, he will have rendered the clinician a real service because of the grave prognostic import of such a diagnosis.

In recent years the differentiation of infarcts from the pneumonias has become more important, since treatment with the sulfa drugs has lowered the mortality in the latter group.

REVIEW OF THE LITERATURE

The first definite papers on the subject of roentgen diagnosis of pulmonary infarction appeared about twenty years ago. In 1922 Wharton and Pierson (12) reported 9 cases, all of which followed abdominal surgery. They described clouding of the costophrenic angle as the earliest sign and stated that the shadows of the infarct, when seen, were sharply defined.

In 1923, Wessler and Jaches (10) stated that large triangular shadows with the base toward the axilla were most characteristic.

In 1924, Kohlmann (6) expressed the opinion that radiological examination might help to clinch the diagnosis in cases of pulmonary infarction in which the clinical evidence was not conclusive. This

[1] Accepted for publication in January 1945

statement reflected the general opinion held at that time, that shadows cast by infarcts were inconstant. It also revealed a lack of clearly established criteria on which a roentgenologic diagnosis could be based.

Rieder and Rosenthal (8), in 1927, made the important observation that in the presence of severe passive hyperemia in the lungs, the infarcts may fail to produce clearly defined shadows.

In 1930, Kirklin and Faust (5) made a clinical and roentgenologic study and reported 25 cases, including 17 in which the infarct had occurred postoperatively and 6 in which cardiac failure was present. They stated: "It is difficult and at times impossible to make a diagnosis of pulmonary infarction from the roentgenograms. With the clinical data, however, the nature of the shadows appearing on the film may usually be accurately determined."

As the evidence has accumulated over a period of years, the varied appearances which an infarct may assume have become more generally understood. More and more dependence has been placed on the roentgenogram to arrive at a diagnosis of a pulmonary infarct. It is probably fair to state that, in most instances of uncomplicated pulmonary infarction, it is possible to make the diagnosis of an infarct, or at least to suspect its presence, from the roentgenogram alone. The clinical data should, nevertheless, always be given due weight. In those instances in which secondary complications alter the roentgen appearance, considerable dependence must be placed on the clinical observations. This point will be discussed further under the appropriate headings.

K. S. Smith (9), in 1938, discussed the roentgen appearance of pulmonary infarcts based on his experience with 13 cases. He stated that the shadows due to infarcts of the lung fall into six groups: hazy horizontal clouding at the base; shadows suggesting pleural effusion; shadows of roughly circular form; density of one part of a lobe with cavity formation; appearance of basal collapse of a lobe; dense linear shadows.

Westermark (11), also in 1938, made the observation that in some instances of pulmonary embolus an area of avascularity can be seen corresponding to the distribution of that portion of the pulmonary artery which is occluded. He stated that the vascular markings leading to the avascular area end abruptly, and that later, if an infarct develops, an area of increased density in that location will be seen.

One year later, Jellen (4) analyzed the roentgen signs of infarcts of the lung and reported 18 cases. Among other things, he stated that the appearance of the infarct shadow may be delayed for several days following the embolic process. He also pointed out the clouding of the costophrenic sinus, the secondary formation of an abscess in some instances, and the fact that there is considerable variation in the appearance of an infarct.

The most complete and thorough investigation thus far is that of Hampton and Castleman (3), published in 1940. Reference to their excellent work will be made at various points in this paper.

CLINICAL FINDINGS

Hemoptysis, with sudden sharp pleural pain, most frequently heralds the onset of a pulmonary infarct. A chill is almost never experienced. Dyspnea is often present. Physical examination will usually reveal râles and a change in the character of the breath sounds. If a peripheral pleural surface is involved, a friction rub may be heard. The physical findings vary with the position and age of the infarct, and are subject to modifications by the occurrence of complications such as pleural effusion and abscess.

There is moderate elevation of the temperature and of the white blood cell count with a relative polymorphonuclear leukocytosis. The low-grade fever persists for several days and, if the patient survives, gradually returns to nomal.

Jaundice occurs occasionally. This may in some instances be due to necrosis of the infarct, but may be the result of the severe passive hyperemia which is present in

Figs. 1 and 2. These two roentgenograms demonstrate that the shape of an infarct is often dependent upon the shape of the portion of the lobe involved. A. M., a white male in his early 20's, was known to have mitral stenosis and had been observed during several episodes of myocardial failure. In the course of one of these, some months before this examination, he had had a pulmonary infarct. These roentgenograms were selected from the group available for this patient, because they most clearly illustrate the shape of the infarct.

Fig. 1. A sharply defined oval shadow of homogeneous density (arrows) is present in the right mid-lung field, just below and adjacent to the interlobar septum. It does not reach the lateral chest wall. The cardiac silhouette is that of mitral stenosis with cardiac hypertrophy and dilatation.

Fig. 2. In the left anterior oblique projection, the shape of the shadow is that of the anterolateral tip of the right middle lobe (retouched for reproduction). There is no resemblance to the "classical" triangle, widest laterally, but instead the broadest part of the infarct is medial. An infarct in such a location must assume the shape enforced by the pleural surfaces.

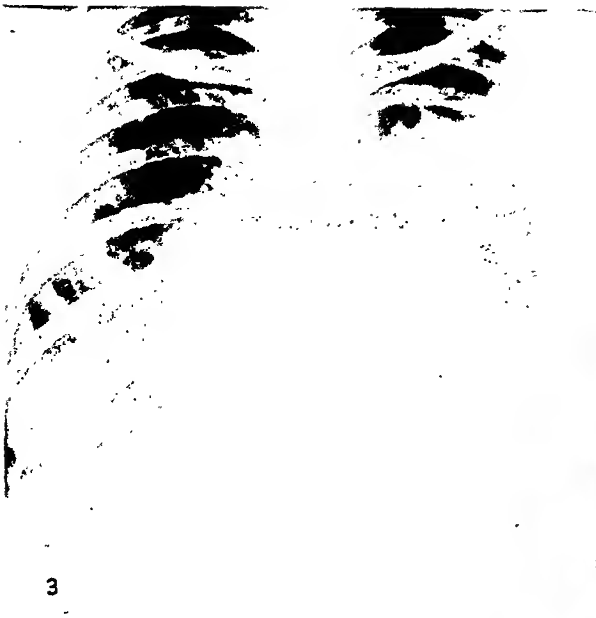
many of the patients with myocardial failure.

While a number of infarcts occur postoperatively, the great majority (in this series, at least) are seen in "medical" patients. Infarcts are more likely to develop in patients with cardiac disease, but a considerable number are seen in the absence of myocardial failure. In the previous study (7) 6 per cent were found to have occurred after surgery. There was evidence of heart disease in 70 per cent, and 24 per cent were in "non-cardiac medical patients." This surprisingly large number of non-cardiac medical cases is, however, quite similar to the findings of Hampton and Castleman (3). Of the 255 instances of pulmonary infarction in their series, 27 per cent were in non-cardiac medical patients. It should be noted, however, that in a patient with cardiac disease occurrence of an infarct is a much more serious event than it is in the absence of myocardial failure (7).

The occurrence of a secondary lung abscess is manifested by a higher elevation of temperature and leukocytosis and by the appearance of a foul, copious sputum, after the original symptoms have subsided. A chill may occur at this stage.

ROENTGENOLOGIC APPEARANCE

Because of the great variation in the appearance of infarcts and the frequency with which the infarct shadows are masked by various complications, repeated examinations are important. Most of these must necessarily be made at the bedside, but this should not be a deterrent, since relatively satisfactory examinations are now possible with any of the modern mobile roentgenographic units. Such units have made possible many diagnoses of pulmonary infarction in patients who were



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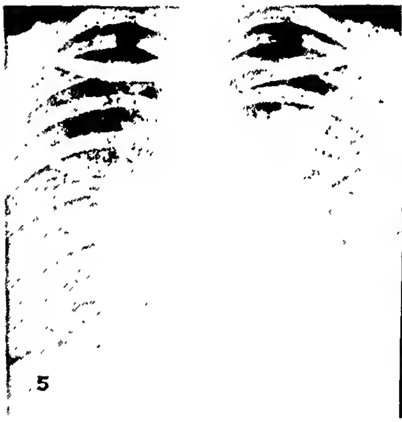

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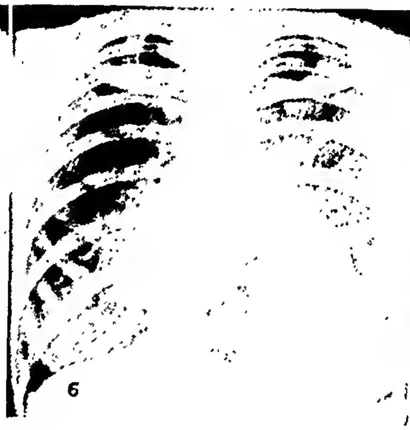

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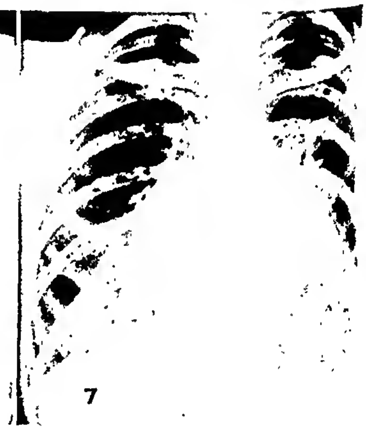

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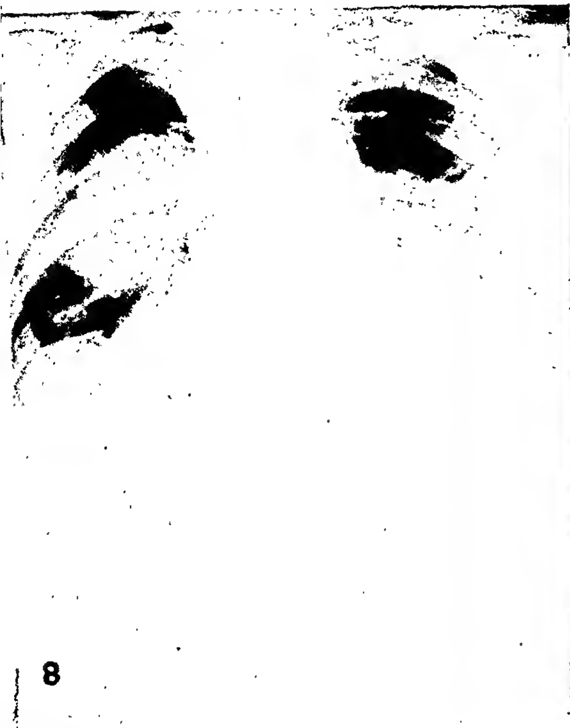
Figs. 3–7. These five roentgenograms show that the sl ct need not be triangular,
varies in different projections, a ne broadest part o be directed toward the h
by fibrosis and the residual fibr e also shown. E. adult white female wh
to the hospital in mild myocard ue to mitral sten nt illness included a hi
hemoptysis.

Fig. 3. A sharply defined, a onal, homogen reased density i
medial portion of the upper half field. The l this infarct sha
heart. There is a small pleural e ft costophre iac silhouette
stenosis with cardiac hypertrophy
Fig. 4. The infarct shadow (arr in the le the anter
and the borders are sharply demarc ortion i heart.
displacement of the esophagus (lowes ard d prima
dilated left auricle.
Fig. 5. One month later the infarc ry l
The small pleural effusion is still present
Fig. 6. Five months after the onset t
cut borders. Strands of fibrous tissue, rep
Fig. 7. Two and one-half years after th
of fibrous tissue radiating in several directio
had been seen at this stage for the first time,
obvious cardiac disease would then have been a

too ill to be examined otherwise. The roe genographic appearances are best d cussed under separate headings, as follow



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Figs. 8 and 9. These two roentgenograms indicate that an infarct may even appear to be round and that its pearance will vary strikingly with the projection in which it is seen. I. B., an 81-year-old colored female, was mitted to the hospital in myocardial failure due to arteriolar nephrosclerosis.

Fig. 8. This roentgenogram, made four days before death, reveals a well demarcated round shadow of in- eased density in the right upper lobe, surrounded on all sides by apparently normal lung tissue. There are her shadows of increased density at the right base (below the interlobar septum) and in the lower two-thirds the left lung field. At autopsy, these latter shadows proved to be areas of confluent bronchopneumonia.

Fig. 9. The right lateral view demonstrates that the round shadow seen in the postero-anterior view is in the sterior portion of the right upper lobe, against the posterior pleura (arrows). The shape in this projection is ughly that of a truncated triangle (retouched for reproduction). The value of additional views to demonstrate e true shape is thus evident. The roentgen diagnosis of an infarct in the right upper lobe was confirmed at the stmortem examination.

as also observed in the previous study (7). 'hen an upper lobe is involved, infarcts ill almost always be found in a lower lobe ; well.

Infarcts may vary from less than 1 cm. . diameter to an area occupying an entire be. Most frequently they measure from to 6 cm. Once developed, the infarct ill vary but little in size (except for heal- g), but complications such as pneumonia, oscess, and pleural effusion may cause a apparent increase in the extent of the adow.

Infarcts are more frequently multiple an single, but only rarely are more than vo or three seen on the roentgenogram. istances of as many as 14 visible infarcts ive been reported (3), but are exceptional.

2. *Shape:* There is no characteristic ape of an infarct shadow. The earlier idea that the shadow as seen on the roent- genogram was triangular, with the base laterad, was drawn from the theoretical concept that infarcts were conical in shape. This has been disproved by Hampton and Castleman (3). By the nature of the path- ologic process an infarct must be so situ- ated that it borders on at least one pleural surface. It follows that the outlines of an infarct shadow are subject to the modifica- tions imposed by the contour of the por- tion of the lobe involved (Figs. 1 and 2). It can readily be seen that an infarct lo- cated at a point in the parenchyma where two or more pleural surfaces meet must as- sume the shape of that portion of the lobe. The variations in the shape of the shadow of a pulmonary infarct are demonstrated in Figs. 1 to 4, 8 and 9, 11, 13, and 18.

It is possible for an infarct to have a

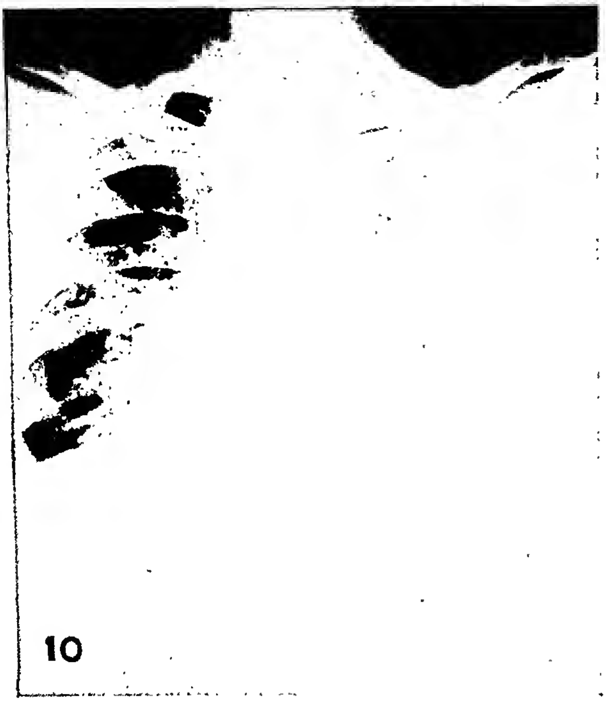


Fig. 10. In this case a pleural effusion completely hides an infarct. T. B., a 56-year-old white male, was admitted to the hospital in myocardial failure. There was a recent history of hemoptysis and fever. The roentgenogram shows a large pleural effusion in the left half of the chest. Following the removal of the fluid (which was blood-tinged and foul), an abscess cavity within an area of consolidation was demonstrated. This was treated surgically, and recovery ensued. Six months later the patient died in cardiac failure and postmortem examination revealed a stellate scar in the left upper lobe, with organized thrombi in the corresponding branches of the pulmonary artery. Thus, on the roentgenogram, a pleural effusion completely obscured a pulmonary infarct. However, because the clinical data were quite definite, the correct diagnosis was made.

conical shape and to present a roughly triangular appearance on the roentgenogram (with the apex truncated and the base peripheral) but, if so, such a triangular appearance can be present in only one projection (Figs. 8 and 9). Unless the base of the infarct is against the lateral chest wall, the roughly triangular shape will not be apparent in the usual postero-anterior projection and will be seen, if at all, in an oblique or lateral view.

Variations in the shape will also be encountered as the result of superimposition of more than one infarct shadow (3). It may be possible to separate such shadows by additional views. Infarcts located in the costophrenic angle may be triangular, but because of the shape of that part of the lung, the widest portion is toward th heart.

In large infarcts, as the result of t collapse of the large numbers of alve the volume of the lung is somewhat r duced, occasionally to a degree simulati collapse of a lobe (3). The diaphrag may be elevated, especially if the periphe pleura is involved.

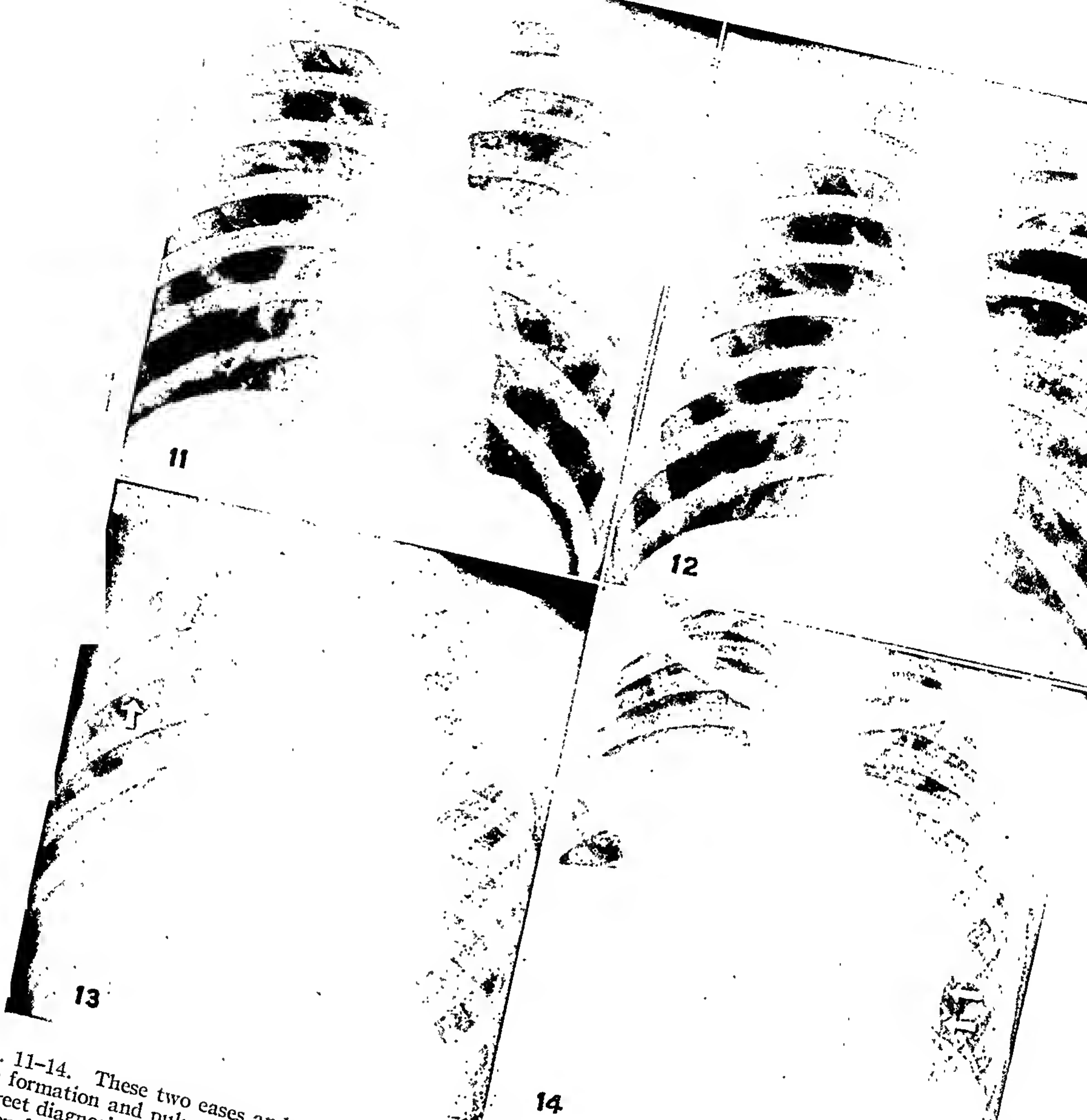
The borders of an infarct shadow a usually sharply demarcated (Figs. 2, 3, 1 and 13). This is especially true of t pleural border or borders, but the pare chymal borders are also relatively clear c At the cardiac side (point of occlusion the artery) the shadow may be sligh fuzzy.

3. *Density:* The shadow of a pulm nary infarct is almost always homogene after the first few hours, and is of moder density in relation to its diameters (Fi 3, 8, 11, and 13). Since the lesion is d to occlusion of a blood vessel, the alveo collapse and necrosis which ensue a quite uniform. The formation of a lu abscess and the process of healing will alt this appearance.

4. *Complications:* The presence of va ous complications may obscure the roe genologic appearance, sometimes qu early in the course of the infarction. previously stated, in such instances it m then be impossible to make the correct d agnosis without help from the clinical dat Roentgen examination should, therefo be made as soon as possible after the on of symptoms.

Secondary *bronchopneumonia* may be within a few days after the onset of t infarct. In such instances, the non-pleu borders of the infarct lose their relativ sharp outline, assume a feathery appe ance, and fade into the surrounding lu parenchyma (Fig. 15).

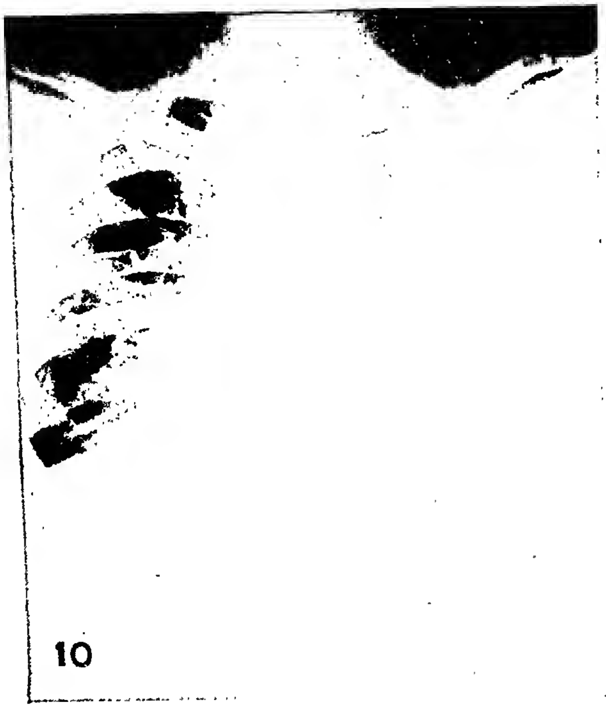
A *pleural effusion* is a distressingly f quent complication. At times an effusi is present before the infarction occu again, it develops soon afterward. some cases the involvement of the perip eral pleura by the infarct is responsi for the effusion; more often, myocard



igs. 11–14. These two cases and that shown in Fig. 15 demonstrate the effect of secondary infection with ess formation and pulmonopleural fistula on the roentgen appearance of an infarct. In all of these cases orrect diagnosis would have been difficult, if not impossible, without the aid of the history, had the patients seen for the first time in the later stages of the illness. With the serial films which were available in each however, the roentgen diagnosis was not difficult.

gs. 11 and 12. T. A., a 20-year-old white male, had hemoptysis and pain in the left side of the chest four after a submucous resection of the nasal septum. On a roentgenogram taken one day later (Fig. 11) there homogeneous shadow of increased density in the upper portion of the left lung field, laterally. It is roughly ıgular in this projection, the lower border is sharp, the upper border fairly well demarcated. our weeks later an abscess cavity about 2 cm. in diameter is visible within the shadow of the infarct (Fig. 12). infarct shadow is no longer homogeneous, but is the seat of fibrosis and retraction indicating some healing.

gs. 13 and 14. F. B., a 28-year-old white male with mitral stenosis, in moderately severe myocardial failure, plained of pain in the right side of his chest and of repeated small hemoptyses. In the left anterior oblique genogram made two days after the first hemoptysis (Fig. 13), there is a clear-cut shadow of even density in nterior portion of the right upper lobe, adjacent to the anterior and the interlobar pleura (arrows), repre- g an infarct. In the postero-anterior view, the shadow was ovoid. ve days later an abscess cavity was demonstrated within the infarct, and the next day a pneumothorax, aining a fluid level was demonstrable (Fig. 14). The right lung is collapsed and adhesions to the chest wall visible. The sharp border of a fresh infarct in the left lower lobe, just lateral to the cardiac border, is also (arrows). At postmortem examination, the same day, the roentgen diagnosis of an infarct in the right upper with abscess formation, pulmonopleural fistula, and hydropneumothorax was confirmed. The pleural fluid oul.



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Variations in the shape will also be encountered as the result of superimposition of more than one infarct shadow (3). It may be possible to separate such shadows by additional views. Infarcts located in the costophrenic angle may be triangular, but because of the shape of that part of the lung, the widest portion is toward the heart.

In large infarcts, as the result of the collapse of the large numbers of alveoli the volume of the lung is somewhat reduced, occasionally to a degree simulating collapse of a lobe (3). The diaphragm may be elevated, especially if the peripheral pleura is involved.

The borders of an infarct shadow are usually sharply demarcated (Figs. 2, 3, ... and 13). This is especially true of the pleural border or borders, but the parenchymal borders are also relatively clear. At the cardiac side (point of occlusion of the artery) the shadow may be slightly fuzzy.

3. *Density:* The shadow of a pulmonary infarct is almost always homogeneous after the first few hours, and is of moderate density in relation to its diameters (Figs. 3, 8, 11, and 13). Since the lesion is due to occlusion of a blood vessel, the alveolar collapse and necrosis which ensue are quite uniform. The formation of a lung abscess and the process of healing will alter this appearance.

4. *Complications:* The presence of various complications may obscure the roentgenologic appearance, sometimes quite early in the course of the infarction. As previously stated, in such instances it may then be impossible to make the correct diagnosis without help from the clinical data. Roentgen examination should, therefore, be made as soon as possible after the onset of symptoms.

Secondary *bronchopneumonia* may begin within a few days after the onset of the infarct. In such instances, the non-pleural borders of the infarct lose their relatively sharp outline, assume a feathery appearance, and fade into the surrounding lung parenchyma (Fig. 15).

A *pleural effusion* is a distressingly frequent complication. At times an effusion is present before the infarction occurs; again, it develops soon afterward. In some cases the involvement of the peripheral pleura by the infarct is responsible for the effusion; more often, myocar

ad to the consideration that they repre-
nt old healed infarcts. They must be
fferentiated from disks of atelectasis and
om interlobar pleurisy. The differential
agnosis is discussed under the appropri-
e heading.

DIFFERENTIAL DIAGNOSIS

The infarct shadow must be differen-
ted from pneumonia of various types,
oplasm, passive hyperemia, pleural
usion, cysts, and atelectasis.

1. *Lobar Pneumonia:* Lobar pneu-
onia is usually manifested by a homo-
neous shadow of increased density, which
y present a sharp border if it reaches an
erlobar surface. Except for the fre-
ent occurrence of a chill, the clinical
story approximates that of an infarct.
e amount of lung parenchyma involved
much greater than that of the average
arct. If the patient is seen early, a
all area of infiltration may be observed
spread rapidly in the succeeding twenty-
ur to forty-eight hours, even though the
tient may be responding favorably to
emotherapy. This very rapid and
rked increase in size of a homogeneous
adow is not seen in an infarct. Shadows
e to lobar pneumonia (as seen in the
stero-anterior view) are usually more
nse than shadows of equal size due to an
arct, since in most instances of lobar
eumonia a greater depth and therefore
ater volume of lung parenchyma is in-
lved. It is rare for an infarct to involve
entire lobe, while a lobar pneumonia
es so very frequently.

Furthermore, serial roentgenograms will
nonstrate that, in many instances, the
dow of a lobar pneumonia begins me-
lly and extends across the lung field
g. 16), whereas an infarct is always in
ntact with a pleural surface from the be-
ning. When an infarct borders on the
eral pleural surface, a clear area is al-
st always present medially (Figs. 11
l 15).

. *Bronchopneumonia:* The shadows
sed by bronchopneumonia are usually
ilar, frequently bilateral, patchy and
mottled. The density of these multiple small areas is uneven, and the edges are fuzzy and fade into the surrounding lung. Most of the areas are not in contact with a pleural surface. On the other hand, the infarct shadow has more clear-cut margins and a more even density; it is always against a pleural surface, and only occasionally are more than two or three infarct shadows visible. Shadows due to bronchopneumonia will show more variation from day to day.

3. *Atypical Pneumonia:* This recently described disease of unknown etiology has little resemblance to pulmonary infarction from a clinical standpoint. The patients are usually not critically ill, hemoptysis is rare, and there is almost always a history of an immediately preceding upper respiratory infection.

Roentgenologically, atypical pneumonia resembles bronchopneumonia, or what some roentgenologists have called "interstitial pneumonia." The same multiple small patches of uneven density, occasionally streaked in appearance, are seen. The margins are hazy, and the patches are surrounded by normal lung. The areas of infiltration occur most frequently in the lower lobes but may be seen anywhere in the lung fields. Not infrequently they are subapical in position.

There is a greater tendency to "migration" than in bronchopneumonia, *i.e.*, resolution occurs in one area while fresh patches appear elsewhere. The differential diagnosis is the same as for bronchopneumonia.

4. *Neoplasms:* Since one of the effects of occlusion of a branch of the pulmonary artery is collapse of alveoli in the area of the infarct, a large infarct may cause sufficient diminution in the volume of a lobe to simulate the collapse produced by an endobronchial neoplasm. Hampton and Castleman (3) have pointed out that the use of an over-penetrated roentgenogram will usually fail to reveal areas of normal lung density within the shadow of the collapsed lobe due to endobronchial tumor, whereas a lobe occupied by several infarcts is more

likely to be of uneven density. They further point out that a collapsed right middle lobe can be differentiated by its shape and by its retraction downward and medially, whereas an infarct shadow in this location does not reach the lung root.

Metastatic tumor nodules may be differentiated by the fact that they are rounded, regardless of the projection in which they are seen. They are often multiple and are rarely situated against a pleural surface. It is rare for an infarct shadow to be perfectly round, and still rarer for more than one to have this appearance. Even when an infarct shadow is relatively round in the postero-anterior view, its shape will vary in other projections (Figs. 8 and 9).

5. *Passive Hyperemia:* Cases of myocardial failure with considerable passive hyperemia in the lung fields will present a rather dense bilateral shadow extending laterally from the hili and fading out toward the periphery. This may cause the outlines of an infarct to become indistinct and to resemble a patch of bronchopneumonia. The shadow resulting from the passive hyperemia, together with the large cardiac shadow, will hide a large portion of the lung fields. If an infarct happens to be situated anteriorly or posteriorly and close to the mediastinal border of the lung, it may be completely hidden (Fig. 21). The problem here is not so much one of differentiation as remembering that this may occur, so that if the clinical story suggests an infarct, roentgenograms in additional projections may be obtained.

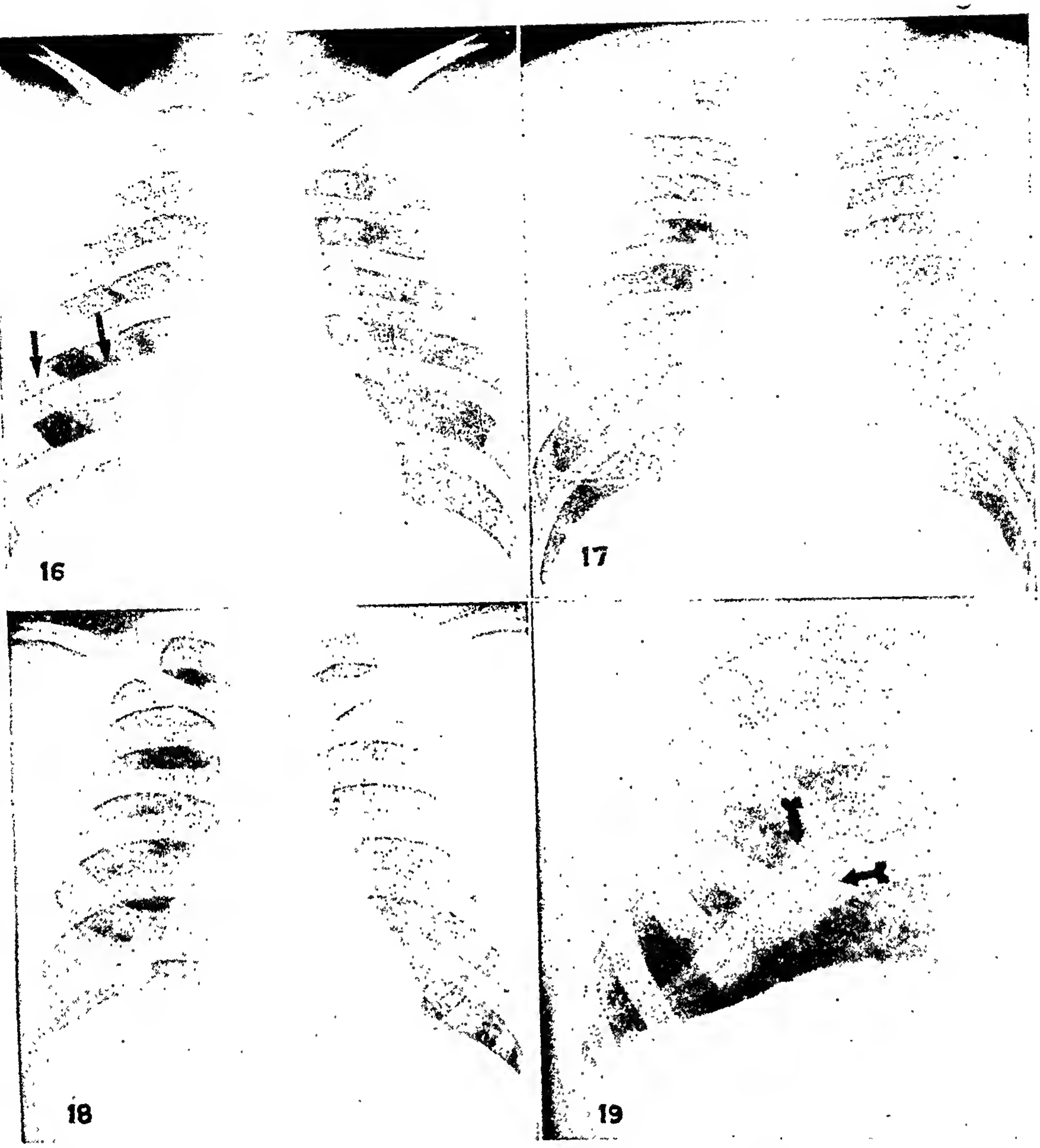
6. *Pleural Effusion:* Differentiation from a pleural effusion, either peripheral or interlobar, is one of the most troublesome problems. In the free pleural effusion, a dense homogeneous shadow is present in the lower lateral portion of the lung field with a smoothly curved upper border, convex downward and higher laterally. An infarct which occurs in the lower lateral portion of a lower lobe may be confused with this, but the upper border of the infarct is more likely to be straight (although not necessarily horizontal) or "humped," *i.e.*, convex upward. The co-existence of the two entities is frequent. The presen of a large obvious pleural effusion wi often mask an underlying infarct (Fig. 1

An infarct with one border against t interlobar fissure on the right may be co fused with an interlobar effusion. An i farct, however, will not be elliptical, a an interlobar effusion almost always The interlobar effusion often extends fr the hilus to the lateral chest wall, or least pleural thickening can be seen reach these points even if the effusion confined to the central portion of the f sure. It would be practically imposs for an infarct in the lower anterior port of the right upper lobe to extend entir across the lung field and still be narr enough to simulate an interlobar effus Furthermore, if the infarct is in the mid lobe, it cannot reach the lateral chest w

7. *Cysts:* Cysts, when they are air-co taining or when a fluid level is prese offer no difficulty in differential diagnos When they are completely filled with fl and only one or two are present, they m present a problem. A fluid level, howeve if not present originally, will usually be d tected on one of a series of examinatio and cysts are rarely situated against pleural surface. Echinococcus cysts m have a calcified border. The rounded co tour of a cyst (in all projections) is important differential point. Different tion is usually not difficult.

8. *Plaques of Atelectasis:* In the ve early stages of an infarct, only a few ho zontal streaks of increased density may visible (Fig. 20). In a matter of a f hours the infarct shadow will assume t more characteristic features already d scribed. Therefore, differentiation fr atelectatic disks is best made by repeat examinations, since the latter will change appearance and often disappear.

More confusing, and more frequently countered, is the problem of different ing between the scar of a healed infa such atelectatic disks, and interlobar p risy. Fleischner, Hampton, and Cast man (2) point out that thickening of t



Figs. 16–19. This group of three cases and that shown in Fig. 20 illustrate the problem of the differential diagnosis between the scars of healed infarcts, interlobar pleurisy, and plates of atelectasis. The occasional simulation of such atelectatic areas by an early infarct is also shown.

Fig. 16. E. W., a 34-year-old white male, was acutely ill. The interlobar pleura (arrows) is seen as a sharp, narrow line extending completely across the right lung field. It is in a slightly lower position than is usually seen, since this is a bedside examination, but it is clearly identifiable as an interlobar fissure. In the medial portion of the right lower lung field there is a dense homogeneous shadow with a fuzzy lateral border, representing a lobar pneumonia in the right middle lobe. The hazy lateral border distinguishes this shadow from that of an infarct. Within twenty-four hours the entire right middle lobe was consolidated.

Fig. 17. S. B. In the lower portions of both lung fields there are horizontal streaks of increased density, single on the left and double on the right. These streaks extend almost completely across the lung fields, are approximately parallel, and represent disk-like plates of atelectasis.

Figs. 18 and 19. F. Y. In Fig. 18 an oval shadow of increased density is visible just above the right leaf of the diaphragm. This represents a pulmonary infarct caused by an embolus from a thrombophlebitis in the leg. The borders are sharply defined and the shadow is of even density. In a coned-down view of the right base made two years later (Fig. 19) a stellate scar of fibrous tissue is seen. This is to be differentiated from a plaque of atelectasis by the fact that the strands are multiple but not parallel, are localized to a small area, and do not extend across the lung field in a horizontal direction. (See also Figs. 3–7 for fibrous scar formation.)

The Roentgen Appearance of Lobar and Segmental Collapse of the Lung

IV. Collapse of the Lower Lobes[1]

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DIAGNOSIS of collapse of individual lobes or segments of lobes requires criteria additional to those which are necessary in collapse of an entire lung or the major part thereof (7, III). Besides the well recognized signs, therefore, the roentgenologist must look for any change from normal in the position of the hili and in the position and contour of the septa, and for rearrangement of the vascular shadows.

Collapse of a lower lobe occurs rather frequently, but it is often overlooked or misinterpreted because the shadow of increased density does not stand out as clearly as in other pathologic processes, such as consolidation. The shadow may be small and so located that it is hidden by overlying structures, as by the mediastinum and diaphragm on the postero-anterior roentgenogram and the spine on the lateral roentgenogram. Roentgenologically, the two lower lobes are essentially alike both in structure and position, so that the appearance of collapse of the whole lobe or of its segments is similar on the two sides. One important difference is that disease processes in the left lower lobe are often obscured by the heart shadow, but with the technic previously described (7, I) this difficulty is overcome. In the 600 cases studied, the left lower lobe was more frequently involved than the right, the left being collapsed in 262 cases and the right in 156.

In the majority of instances, it is possible, with satisfactory technic, to demonstrate the location of the septa which bound the individual lobes (7, II). Roughly, each major septum runs from the level of the fifth thoracic vertebra posteriorly to a point near the anterior portion of the diaphragm. The pulmonary structures seen posterior to the greater septa represent the lower lobes. On the right side a fair portion of the lower lobe is behind both the upper and middle lobes, while on the left, the upper lobe and the lingular portion lie in front of the lower lobe. The remainder of the lower lobe lies below the shadow of the dome of the diaphragm. It is evident, therefore, that the postero-anterior projection essentially the entire lower lobe on each side is either superimposed on shadows of the adjoining lobes or is obscured by the diaphragm.

Frequently the first evidence to suggest a decrease in size of a lower lobe is the demonstration on the lateral roentgenogram of change in the normal position of the major septum, which appears to lie further posteriorly than usual. Shortly after this becomes evident, it is observed that a large number of the pulmonary markings of the lower lobe tend to radiate from the hilus downward and posteriorly just anterior to the spine, where they fan out anteriorly and posteriorly in gentle curves. As the collapse progresses, it soon becomes apparent that there is actual crowding together of the lung markings and that the collapsing lung occupies less and less space. At this stage the closely grouped pulmonary markings stand out as a definite shadow of increased density in contrast to the adjacent uninvolved lung. The middle lobe, or the lingula, and the adjoining portion of the upper lobes will then appear emp- ematous, filling the space formerly occupied by the collapsed lower lobe, which has now moved posteriorly and medially.

Collapse of an entire lower lobe casts a shadow of increased density of rather d

[1] From the Department of Radiology, Massachusetts General Hospital, Boston, Mass. One of a series of p accepted for publication in October 1944.

Fig. 1. Collapse of right lower lobe due to epidermoid carcinoma, grade 3.

1. The shadow of increased density, due to the tumor and the collapsed right lower lobe, obscures the right border of the heart and the medial and posterior half of the right diaphragm.
2. The right upper and middle lobes show emphysema. It is particularly marked in the middle lobe.
3. The minor septum extends to the posterior chest wall. The major septum on the left is in normal position.
4. The right hilus is slightly low in position.
5. The mediastinum is displaced to the right.

(A small amount of retained iodized oil is seen in the region of the middle lobe.)
Pneumonectomy was performed.

acteristic shape and position in the chest (4). In many cases, it has been possible to follow the actual development of this shadow from the first interference with aeration of the lobe, and consequent failure to change from the expiratory to the inspiratory phase, to the final stage, when the lobe is seen as a dense mass of atelectatic lung lying posteriorly and medially in the pleural cavity. In acute obstruction, this process will take place much more rapidly than in chronic collapse. The shadow appears as a pyramidal area of increased density with its apex at the inferior portion of the hilus and its base posteromedially on the diaphragm. It usually obscures the immediately underlying diaphragm and adjacent postero-inferior thoracic wall. (It should be noted that the lobe can be considerably decreased in size without a great amount of atelectasis being visible; the comparative difference in density of this shadow of collapsed lung and the adjoining lung is slight.) If the lesion is a chronic one, in which secondary fibrosis is set up, as in bronchiectasis, the patient may go for years in a stationary phase, showing, on roentgen examination of the chest, findings such as those described above (Figs. 1 and 2). In bronchiectasis, the shadow cast is often described as a triangular shadow of increased density (3). As collapse of the lobe becomes marked, the space formerly occupied by it is filled with the adjacent emphysematous lung. If the cause of interference with aeration of a lower lobe is acute and is relieved, the process will reverse itself and the shadow will disappear.

Not only may the diaphragm be elevated and show diminished motion but, in the earlier phase of collapse, a large portion of it may be obscured by the decreased aeration in the involved lower lobe; if the atelectasis progresses to become complete, the diaphragm is increasingly obscured, with eventual loss of definition of the portion in contact with the collapsed lobe. In chronic cases, the collapsed lower lobe occasionally moves so far posteriorly

Fig. 2. Collapse of the left lower lobe due to adenoma of the left lower lobe bronchus.

1. The edge of the shadow of increased density is seen through the heart shadow (arrows).
2. The left hilus is low in position.
3. All of the visible air on the left side is in the upper lobe.
4. There is elevation of the diaphragm.
5. In the lateral view, the arrows indicate the space occupied by the shadow of increased density. Note the loss of definition of the posterior portion of the diaphragm and the adjacent chest wall.

A left lower lobectomy was performed.

and medially, and occupies such a relatively small area in the chest, that the dome of the diaphragm will be projected above the obscured portion, thus giving the impression, in both postero-anterior and lateral roentgenograms, that the entire diaphragm is sharply outlined. When this occurs, it becomes necessary to study the entire surface of the diaphragm, preferably first by fluoroscopy, in order to demonstrate that a portion is obscured by atelectatic lung above. In many instances, particularly in chronic collapse of a lower lobe, it may not be possible to demonstrate elevation of the diaphragm, shift or displacement of the mediastinum, or narrowing of the rib spaces.

As a lower lobe decreases in size, the hilus tends to move into a lower plane, and its inferior portion may be assimilated in the shadow of increased density. This perhaps explains why the hilus at times appears to become smaller. At other times the displacement of the hilus may carry it behind the shadows of superimposed structures, again creating an impression of decrease in size. In general, the depression of the hilus varies with the degree of collapse, but in certain instances, as in the presence of a fairly large tumor or of collapse in a basilar segment with marked emphysema in the dorsal division, the depression, if present, may be only slight. Change in the position of the hilus may be readily observed in patients whose collapse is of a temporary nature, for with complete re-expansion of the lobe the hilus resumes its normal position.

Any marked change in the position or contour of the septa may be of importance in determining the area of the lung in which collapse is present and the degree to which it has progressed. This is particularly true in segmental collapse. The septa have been previously noted as being normally straight or gently curved lines (7, 11). When an entire lower lobe is collapsed, the major septum retains its usual contour but

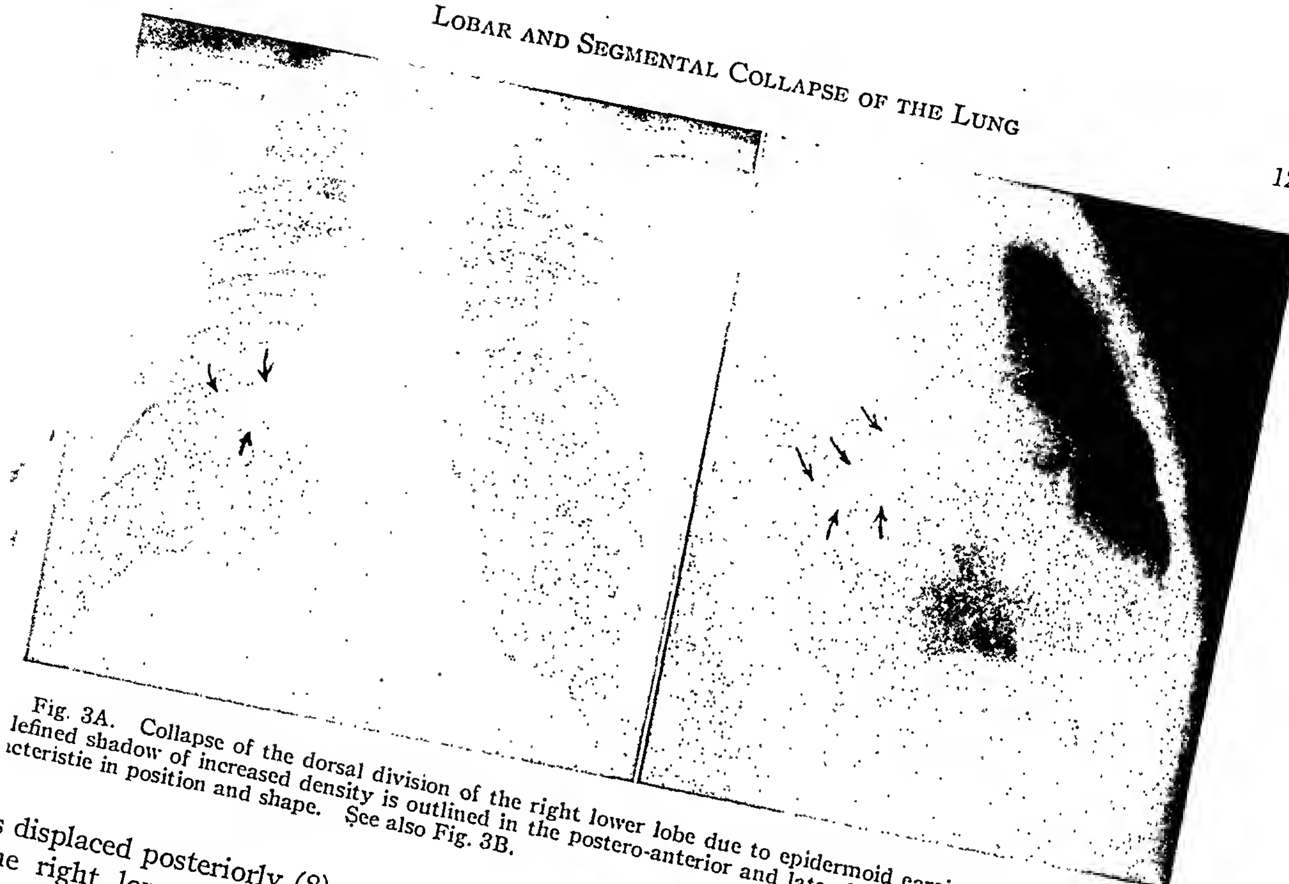

Fig. 3A. Collapse of the dorsal division of the right lower lobe due to epidermoid carcinoma. The sharply lefined shadow of increased density is outlined in the postero-anterior and lateral roentgenograms and is char-ıcteristic in position and shape. See also Fig. 3B.

's displaced posteriorly (8). In collapse of he right lower lobe, the minor septum nay extend to the posterior chest wall, since the middle lobe may occupy all of the urea directly adjacent to the diaphragm except the small part occupied by the ollapsed lower lobe. Furthermore, the inor septum is often, though not always, splaced downward from its normal posi-ion.

Rearrangement of the uninvolved lung djoining the collapsed lower lobe explains he development of compensatory emphys-ma which is always present and usually ppears as a variation in brightness in the ung fields. This apparent brightness is aused by decrease in the number of vascu-ar markings and the other shadows per nit area. The normal vascular shadows have been separated (and therefore less-ned in number) by the increased size of the ir-containing spaces. Comparison of the mphysematous lung with the opposite ormal lung will show that it contains con-iderably fewer opaque structures.

It should be stressed that, because of the natomic arrangement of the bronchi, a lesion which completely occludes the bronchus to the right lower lobe may also oc-

Fig. 3B. Same case as Fig. 3A: left anterior oblique bronchogram. The shadow of density is outlined by arrows. There is no filling of the dorsal division bronchus. Right pneumonectomy was performed.

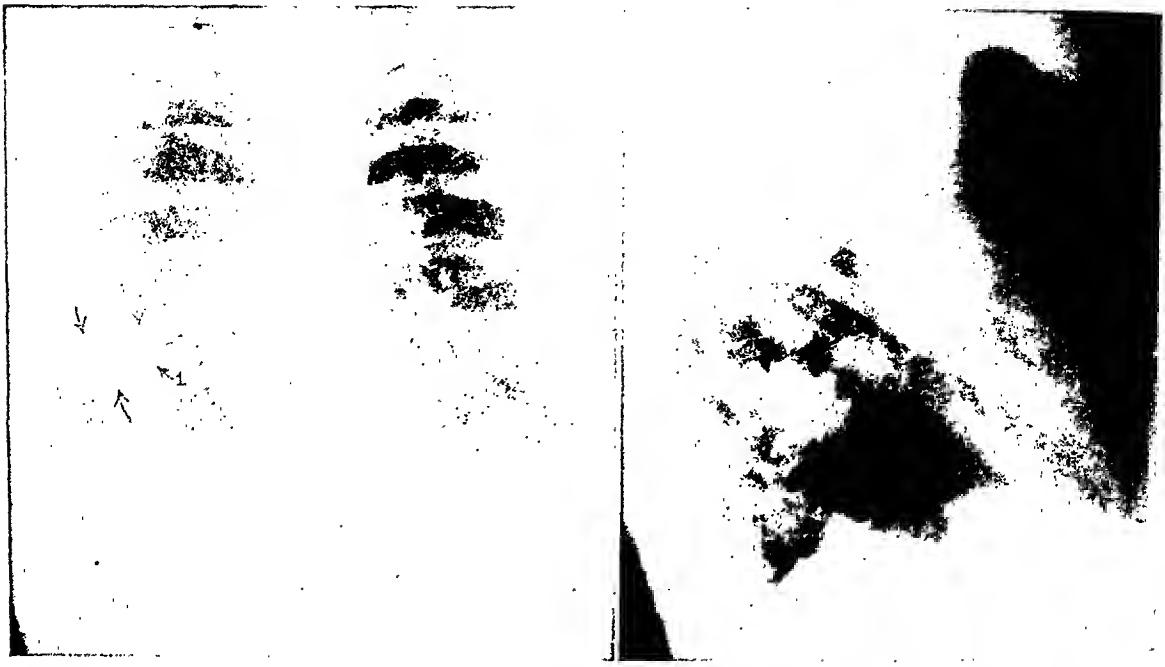

Fig. 4. Atelectasis of the posterolateral segment of the right lower lobe with broncholiths and bronchiectatic abscess. Arrows outline the shadow of increased density. The figure 1 indicates one of the broncholiths. A right lower lobectomy was performed.

clude that of the right middle lobe, so that simultaneous collapse of the right middle and lower lobes is of frequent occurrence. Stenosis of the left lower bronchus, on the contrary, affects the left lower lobe only, since the bronchus to the lingula, the correlative of the right middle lobe, arises from the left upper lobe bronchus. In bronchiectasis, however, the lingula is often found to be involved in combination with the left lower lobe. In a few cases, a collapsed lower lobe was seen to lie very much farther anteriorly than has been described, and this was interpreted as representing congenital collapse. This supposition has not, however, been proved.

For practical purposes the lower lobe can be divided into the posterior upper portion, or the so-called dorsal division, and the basal portion. The bronchus to the dorsal division of the lower lobe arises from the main bronchus at the level of the middle lobe orifice on the right and just distal to the upper lobe orifice on the left. The basal portion, composing the remainder of the lower lobe, occupies the space posterior to the middle lobe on the right and the lingula on the left.

Collapse confined to the dorsal division of the lower lobe (Fig. 3) is encountered somewhat less frequently than collapse of the basal portion or collapse of the entire lower lobe. It can be recognized without great difficulty, since it produces a rather characteristic shadow with a definite localization and a marked change in the appearance of the septa. The shadow of increased density, as in collapse of the entire lower lobe, is due to the drawing together of normal structures. A very small area of atelectasis may result, which in the postero-anterior projection is seen to have a rather sharp upper margin and to lie slightly below the hilus. It is often misinterpreted as an area of segmental collapse of the middle lobe. The lateral view, however, shows it to be located posteriorly in the chest, occupying part of the space ordinarily filled by the fully expanded dorsal division. In both projections, there is a tendency for the shadow to assume a triangular shape. In the postero-anterior roentgenogram the base lies against the mediastinum and the apex extends laterally, whereas in the lateral view the apex is directed posteriorly and the base lies

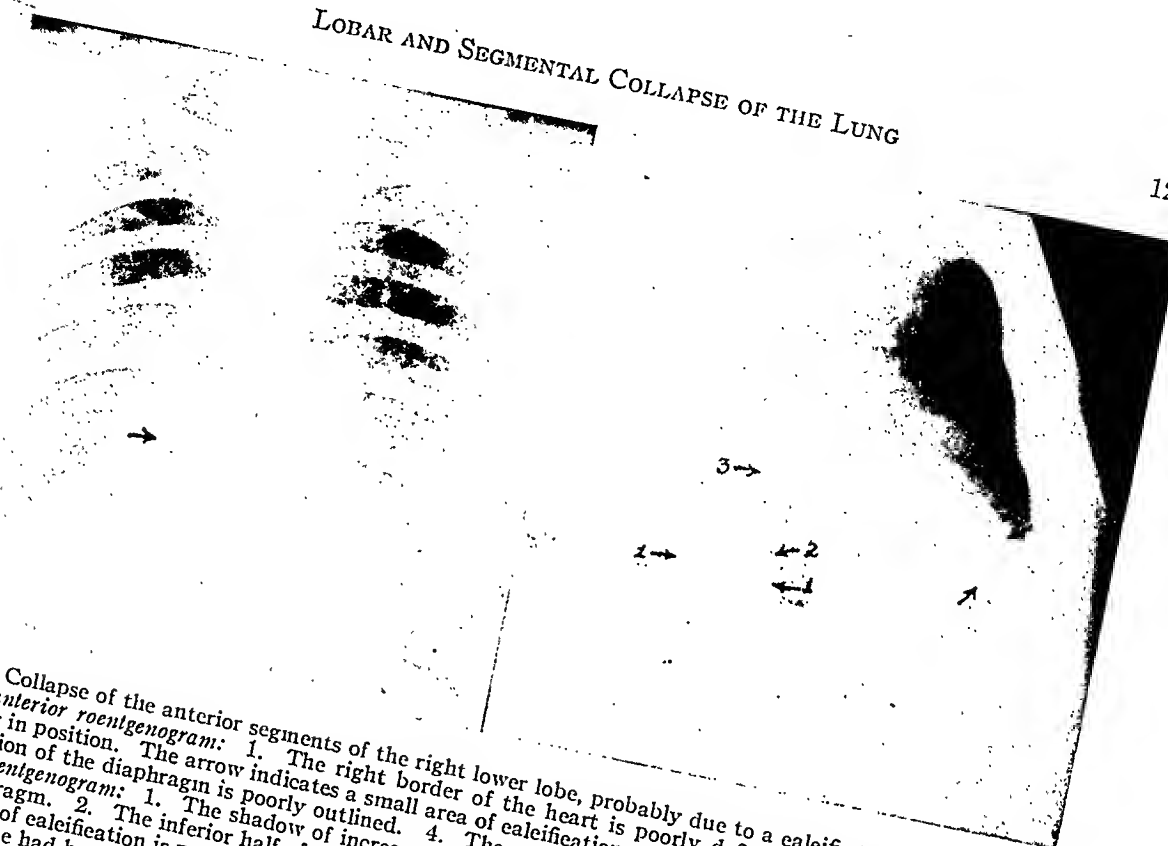

Fig. 5. Collapse of the anterior segments of the right lower lobe, probably due to a calcified node.
Postero-anterior roentgenogram: 1. The right border of the heart is poorly defined. 2. The right hilus is lightly low in position. The arrow indicates a small area of calcification which was later expectorated. 3. The edial portion of the diaphragm is poorly outlined. 4. The mediastinum is displaced to the right.
Lateral roentgenogram: 1. The shadow of increased density is seen with its base obscuring the posterior half f the diaphragm. 2. The inferior half of the major septum shows a marked curve and is displaced posteriorly. The area of calcification is present at the apex of the collapsed area. (Incidental collapse of the lingula of the ft upper lobe had been present for years.)
Follow-up roentgenograms after expectoration of the calcified node showed marked improvement and nearly omplete re-expansion of the right lower lobe.

gainst the major septum. The position f the superior portion of the major sep- um is greatly changed. It is much lower han normal, the angulation usually oc- urring in the mid chest—on the right side t the junction of the major and minor epta, on the left at approximately the ame level. Ordinarily, the hilus is not ppreciably depressed, but a small amount f compensatory emphysema in the adja- ent portions of the upper lobe or in the asilar portion of the lower lobe may be lemonstrated. It is of some importance o note that bronchiectasis may spare the lorsal division when the remainder of the ower lobe is involved, whereas tuberculosis nd lung abscess frequently involve the pical portion of the lower lobe.

In the group studied, collapse of the asilar portion of the lower lobe was more requently seen than collapse of the entire obe or of its dorsal division. With future dvance in thoracic surgery, further subdi- ision of the basilar portion will probably be required. Various classifications for such subdivision have been suggested (1, 2, 5, 6). The importance of classifica- tion is that there should be agreement be- tween the roentgenologist and the surgeon. Due to lack of sufficient proof, no detailed discussion of the appearance of collapse of segments of the basilar portion of the lower lobe can be given (Figs. 4 and 5). There have been numerous instances in the presence of foreign body, so-called atypical pneumonia, and other disease processes, in which it was thought that there was atelectasis or collapse of one or more of these segments, but in very few was absolute confirmation obtained.

Actually the basal portion represents about two-thirds of the bulk of the lower lobe, and its appearance when collapsed (Fig. 6) is very similar to that of collapse of the entire lobe. It differs in that the shadow of increased density is somewhat smaller, and posteriorly, between it and the posterior chest wall, there is downward

Fig. 6. Collapse of the basal segments of the left lower lobe due to mucous plug in the left lower lobe bronchus distal to the dorsal division bronchus.

Postero-anterior roentgenogram: 1. The shadow of increased density is visible through the heart shadow. 2. The hilus is only slightly low in position. 3. The left diaphragm is slightly elevated.

Lateral roentgenogram: 1. The shadow of increased density represents complete collapse of all of the segments of the lower lobe except the dorsal division. 2. The anterior portion of the diaphragm is clearly visualized, and the emphysematous upper lobe extends back to the major septum, which forms the anterior margin of the shadow of increased density.

extension of the emphysematous dorsal division. The shadow cast by the collapsed basal segments obscures only the posterior portion of the diaphragm and is not in contact with as much of the posterior chest wall as the shadow of the collapsed entire lobe. The middle lobe moves somewhat posteriorly, but less so than in complete collapse of the lower lobe. The hilus is often displaced inferiorly, but the amount of displacement is dependent upon the degree of compensatory emphysema in the dorsal division. In other words, the greater the emphysema, the less the inferior displacement of the hilus. As in collapse of the entire lobe, there may be less inferior displacement of the hilus if a tumor composes part of the shadow of increased density. The major septum is usually visualized without difficulty, but that portion below the dorsal division always lies posterior to its normal position. Frequently some limitation of motion, as well as slight elevation, of the diaphragm is evident.

Acute collapse of the dorsal division, of the basilar division, or of its subdivisions is similar to acute collapse of the entire lobe in that it may be reversible, the changes being easily observed on serial roentgenograms.

Occasionally the collapsed segment of a lower lobe may be surrounded by emphysematous blebs arising from the involved pulmonary segment. When this occurs, it tends to limit somewhat the spatial rearrangement of the remaining uninvolved portions of the lobe and thereby may detract from the significance of the signs which have been used to determine collapse. Correct diagnosis will then depend largely upon the actual appearance of the shadow of increased density.

It has not been our intention to deal with collapse of different portions of the lung as a disease entity, but rather as a manifestation of various disease processes. Early diagnosis of a particular process such as bronchiectasis or neoplasm, may depend on the early recognition of the

ırticular manifestation or sign. If any rt of a lung appears smaller than normal, fails to assume its share in the phases of spiration, collapse of that part should be nsidered. Unless complete examination the chest (7, I) has been made, the roentnologist is not justified in reporting negative (and then only with certain ıderstood reservations) the examination any patient who complains of frequent ›per respiratory infection, chronic bronıitis, or persistent pain. In interpreting ıe roentgenograms of such a patient, any ıange from normal in the shape or posiɔn of the septa should be noted. If associated change in the position of the hilus rearrangement of the vascular shadows ıggesting interference with aeration occurs, ›llapse of some degree should be strongly ıspected, and more careful observation ıay reveal the presence of an ill defined ıadow of increased density representing collapsed portion of the lung.

CONCLUSIONS

Collapse of a lower lobe has been a comıon finding in the group studied, being resent in approximately two-thirds of the ıses.

Rearrangement of the vascular shadows, depression of the hilus, and demonstration of an actual decrease in size of a lobe or segment, by means of changes in the position or contour of the septa, are of importance in the diagnosis of collapse of the lower lobes.

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The Value of Gastric Pneumography in Roentgen Diagnosis[1]

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THE ROENTGEN signs of disease in the pancreas, both benign and malignant, have been adequately covered by numerous writers. The complete review offered by Case in 1940 (3) leaves little to be desired, as he reviewed thoroughly all of the literature. More recently Borak (2) has also discussed the roentgen findings. The most striking fact apparent from these papers is the difficulty of making an early diagnosis of disease or tumor in the region of the body and tail of the pancreas. The diagnosis of enlargement of the head of the pancreas was well covered by Case (3) and subsequently by Rendich *et al.* (9). The routine methods of both clinical and roentgen examination may reveal the presence of a mass in the upper abdomen, but too frequently accurate localization of this mass is impossible, and the need for further information is felt. Gastric pneumography may be useful in just such cases.

Since 1933, when Engel and Lysholm (4, 5) introduced gastric pneumography as an aid in the diagnosis of pancreatic disease, the method has been widely quoted, but usually with an air of "this is included for the sake of completeness" (7, 9). Berk (1) in his review does not mention the procedure. No attempt has been made in the American literature to evaluate the method *per se*. Borak (2), in his review, agrees with Paul (8), whom he quotes: "The difficulty is that it is not applicable as a routine method. . . unless some positive findings are present, the examiner does not know which cases may need such an added examination." Paul himself introduces his comment by observing that "the early symptoms and signs [of carcinoma of the pancreas] are by themselves not distinctive and are similar to those associated with other intra-abdominal le-

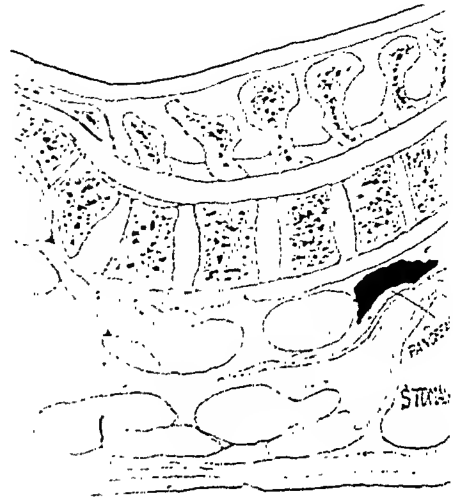


Fig. 1. Sketch (after Engel and Lysholm) of sagittal section through the mid-line at the level of pancreas and stomach, showing clearly the rela- ship of the two organs in the same projection as used gastric pneumography.

sions. In certain cases the difficulties arriving at a diagnosis may appear ins- mountable." Where there is so mu- difficulty in arriving at a diagnosis, a additional information which can be o- tained by a different method of exami- tion must be worth seeking. This w- pointed out by Case (3), when he wro- "The method constitutes a very definite a- vancement in the roentgenography of t- pancreas."

With these thoughts in mind, we at- tempted to obtain gastric pneumogra- in a series of 38 cases where the routine cli- cal and roentgen examinations pointed to lesion of or near the body or tail of the pan- creas, and some further aid in localizati- or diagnosis was needed. Review of the cases appeared to be worth while in ord- to emphasize the diagnostic points an- bring this method of examination to th- attention of those radiologists who ha- not already used it.

[1] From the Department of Radiology of Stanford University School of Medicine and San Francisco Hosp-
Accepted for publication in October 1944.

TECHNIC

The use of any new technic is beset with difficulties, and all too often the procedure is discarded without full trial because of primary failures. The technic used by us differs from that of the original procedure described by Engel and Lysholm in 1933 and 1934 (4, 5). Their method of distending the stomach with effervescing powders and carbonated water was attempted, but the type of patient with whom we were dealing and the undesirable presence of the fluid in the stomach (Fig. 4) made us seek a variation. We made use of a small-caliber stomach tube, which served first for aspiration of gastric contents and then inflation of the stomach. The patient was laid prone with high supports under the chest and pelvis. This was done to insure a normal contour of the posterior wall of the stomach which silhouettes the retro-gastric space. The beam of rays is horizontal, and a vertical Bucky diaphragm is used. The patient is centered before undertaking the last step, the insufflation of air into the stomach, which must be followed immediately by exposure of the film. The amount of air is not predetermined but is governed by the ability of the patient to restrain regurgitation. The quantity varies from 300 to 800 c.c. The smaller amount is not so satisfactory but may be used in less tolerant patients. The purpose of the immediate exposure of the films is to avoid filling the upper small bowel with air and thereby obscuring the outlines of the stomach. Only one or two exposures are attempted at a time. If these are unsatisfactory, one should not persist but should re-examine the patient at a later date. The exposure factors are those used for lateral gastro-intestinal films.

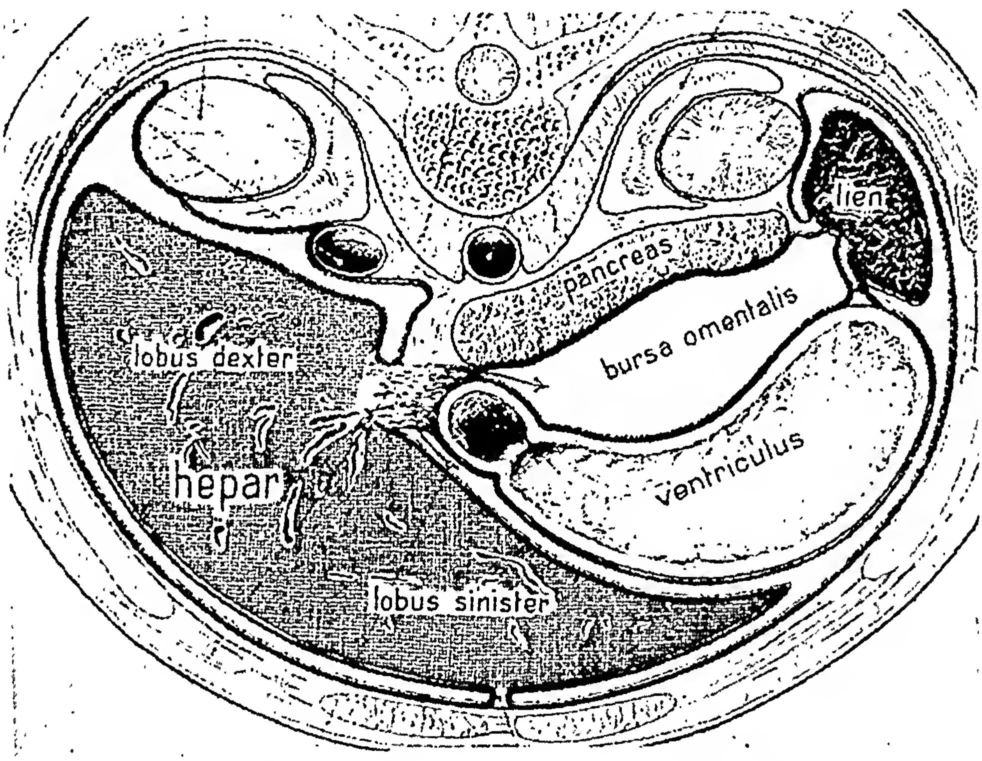


Fig. 2. Sketch (after Sobotta and McMurrich) of a cross-section at the level of the stomach and pancreas, illustrating further the relation of the pancreas to the stomach, as well as the relationship of the other upper abdominal viscera.

We do not feel that a postero-anterior view of the gas in the stomach is necessary. In all of our cases routine gastro-intestinal examinations had been done, and

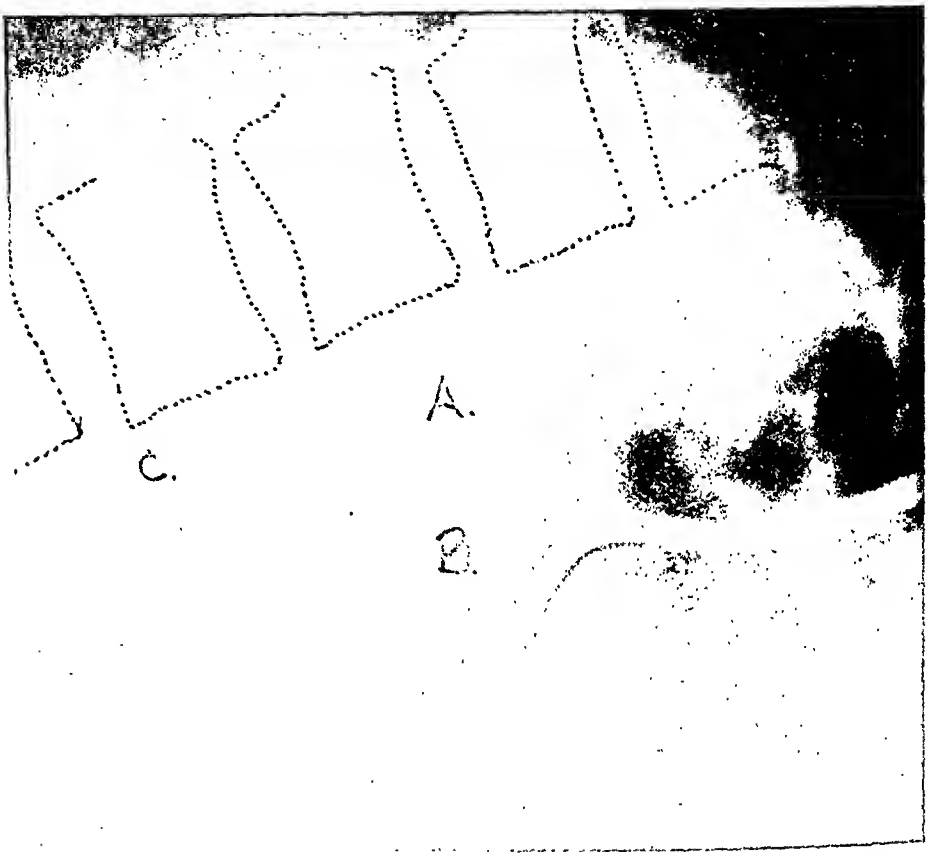


Fig. 3. Normal gastric pneumogram. G. W., 64-year-old male, complained of abdominal pain and weight loss of 20 pounds over a period of three months. An upper abdominal mass 12 cm. in diameter was felt. Gastro-intestinal studies showed no displacement of the stomach and it was felt that the mass was in the left lobe of the liver, lying slightly anterior and to the right of the stomach. Pneumograms of the stomach revealed no enlargement of the retrogastric space. The outline of the pancreas appeared normal. The patient died two weeks after the examination. A hepatoma was found in the left lobe of the liver. The pancreas was normal in size, shape, and position.

A. Silhouette of retrogastric space (a normal pancreatic shadow).
B. Stomach distended with air.
C. Gas in duodenum and barium in colon.

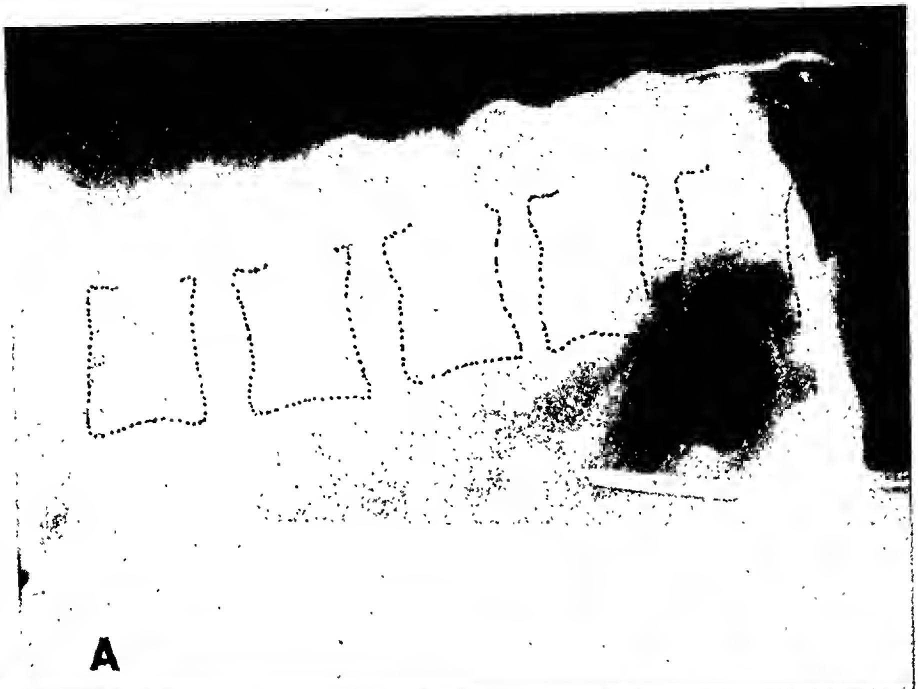


Fig. 4. A. Pneumogram with fluid in the stomach. H. N., 63-year-old male, complained of progressive weakness for four months and jaundice for ten days. Physical examination revealed a large nodular liver and epigastric mass. A gastric pneumogram was reported as "not revealing any increase in the retrogastric space." Autopsy, a few days later, revealed a large carcinoma of the body of the pancreas, which had spread to the draining lymph nodes and to all the abdominal viscera. The tumor with the involved nodes created a large retrogastric mass. This was not outlined pneumographically because the fluid in the stomach dammed off its distal portion.

B. Reconstruction of the shadow which was not shown.

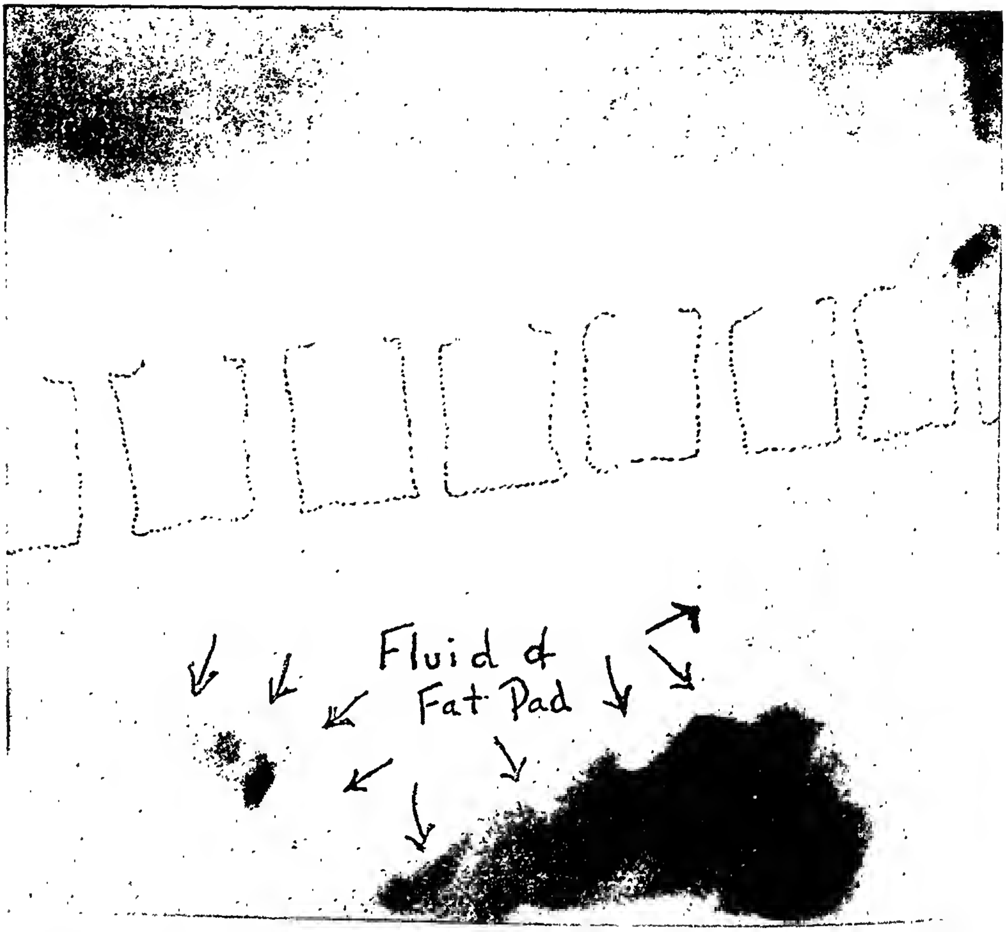
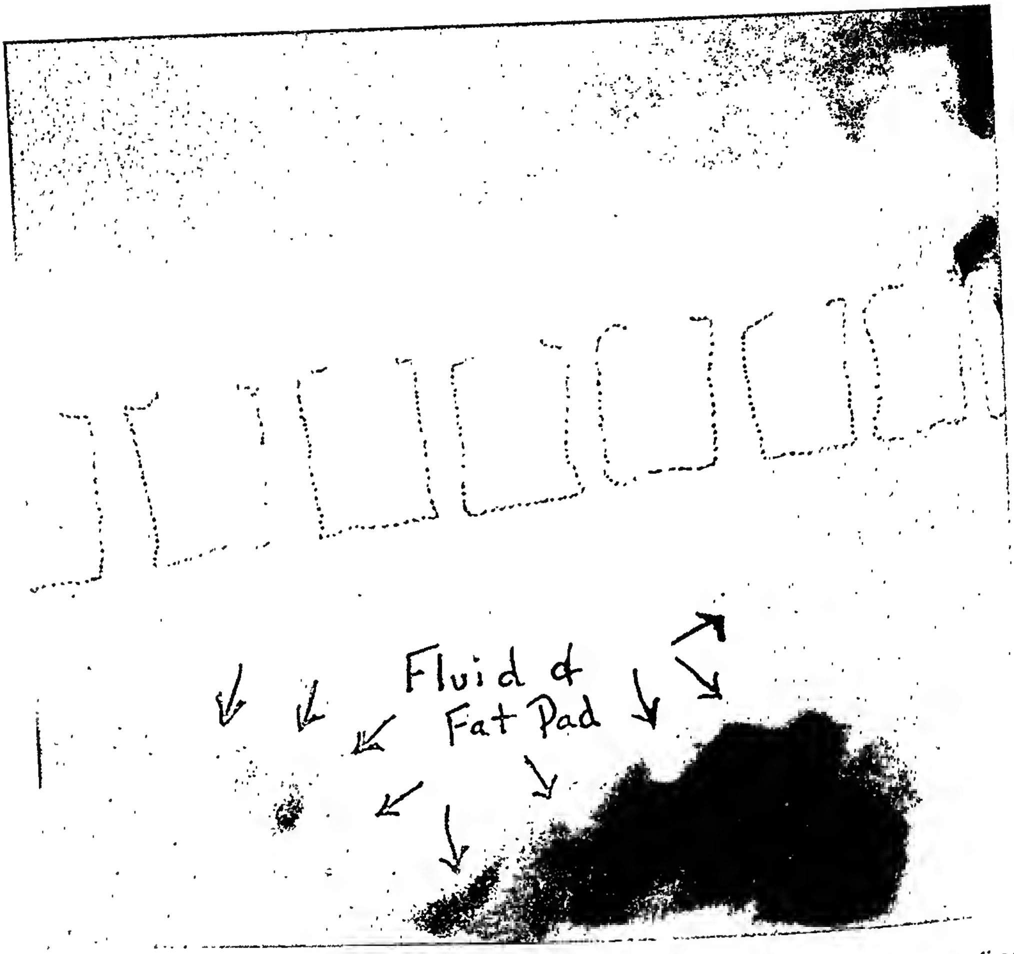


Fig. 5. Fluid and fat in the lesser omental sac. M. A., 48-year-old female, had jaundice of five weeks' duration. The liver was barely palpable and smooth. No epigastric masses were felt. No signs of peritoneal fluid were elicited. Gastro-intestinal examination showed the stomach to be displaced anteriorly and upward. The duodenal loop was exaggerated. The second portion of the duodenum never completely filled and there was a 10 per cent gastric residue at six hours. Gastric pneumograms revealed increase in the retrogastric space which was taken to indicate an enlarged pancreas. A diagnosis of tumor in the pancreas was made. At operation, cirrhosis of the liver was found with gross enlargement of the liver, fluid, and a large fat pad in the lesser omental sac, the combination producing the expansion in the retrogastric space demonstrated on the film. The pancreas was normal in size, shape, and position.

Fig. 6. Fat pad in lesser omental sac in a very short obese patient. G. M., 31-year-old male, entered the hospital with the diagnosis of an "epigastric mass, probably pancreatic cyst." He had had upper abdominal pain intermittently over a period of two years. Gastro-intestinal studies were felt to confirm the impression of a pancreatic mass. Gastric pneumograms showed a marked increase in the thickness of the retrogastric tissues, which was felt to be still further confirmation of a pancreatic mass.

At operation a large lesser omental sac fat pad was found to be the cause of the increase in the thickness of the retrogastric tissues. No cause for the upper abdominal pain was found.



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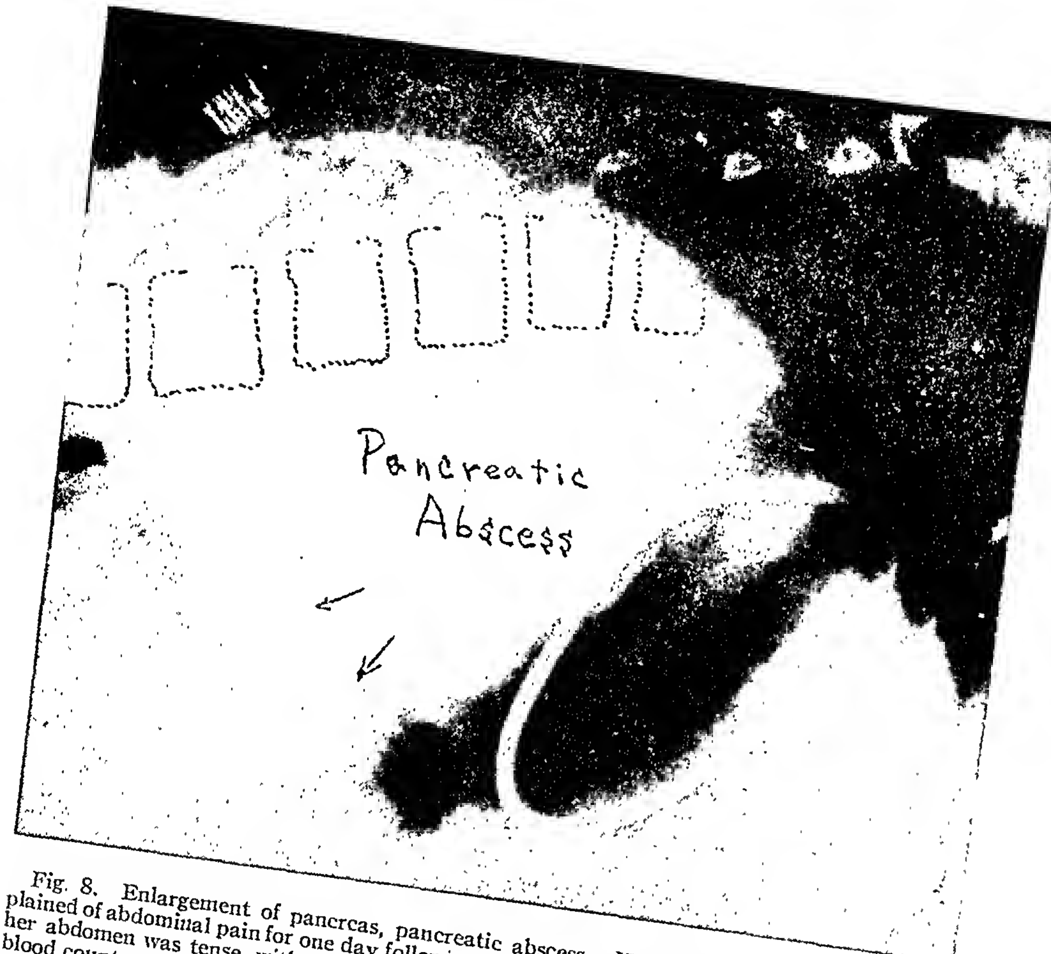

Fig. 8. Enlargement of pancreas, pancreatic abscess. H. S., 29-year-old female, complained of abdominal pain for one day following an alcoholic spree. On physical examination her abdomen was tense, with tenderness and guarding in the upper quadrants. The white blood count was only 9,000. The pain subsided in twenty-four hours, but the patient went into an acute bout of delirium tremens, despite sedation and fluids. She was sent to the psychiatric ward for further observation and treatment. As she cleared mentally, the abdominal pain returned and the serum amylase was found to be 313 units. Finally, two weeks after entry, an upper abdominal mass was palpated. Gastric pneumograms showed a tense, lobulated mass posterior to the stomach. At operation a pancreatic abscess was drained. The fluid from the abscess was tested for amylase and found to give a reaction of 5,000 units. A culture showed *E. coli*. After a stormy postoperative course, with formation of a right lower quadrant abscess which necessitated drainage, the patient recovered fully.

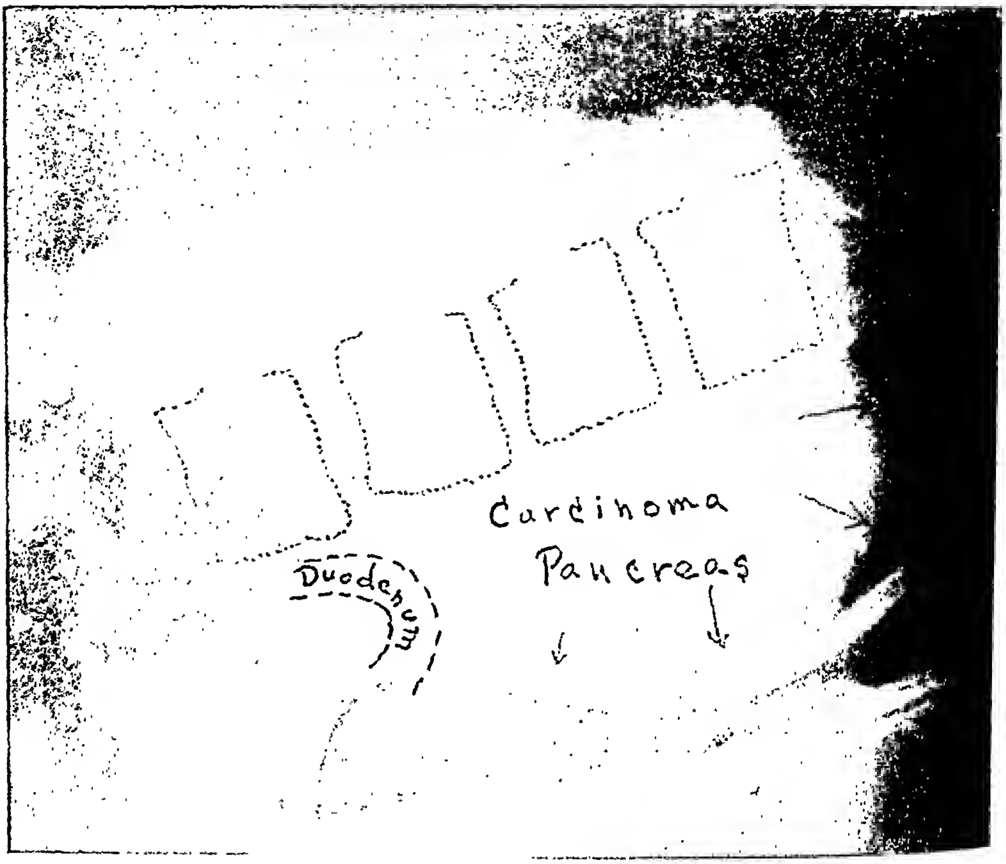

Fig. 9. Enlargement of pancreas, carcinoma in tail of pancreas. C. S., 64-year-old male, gave a history of pain in the left upper quadrant and epigastrium for one month. He had lost 24 pounds. On physical examination a 7 × 4.5-cm. mass could be felt. It was firm, slightly irregular, and tender. The liver was also irregular and tender. The clinical impression was a retroperitoneal tumor, but following a gastro-intestinal series, a diagnosis of pancreatic or gastric tumor was suggested. The gastric pneumogram shows the large mass in the region of the pancreas. The barium-filled diverticula in the colon are also seen.

At laparotomy a diagnosis of carcinomatosis was made, probably arising from the pancreas. The patient died three days after operation and at autopsy a large carcinoma was found originating in the tail of the pancreas with spread to practically all the abdominal viscera.

position and shape of the stomach were ›wn.

INTERPRETATION

'he anatomy of the region about which are concerned is best shown by topophical sketches in two planes (Figs. 1 . 2), as found in Engel and Lysholm's ;inal article and Sobotta and McMur-.'s *Atlas* (the latter reproduced by Bo-).

;ngel and Lysholm believed the normal :kness of retrogastric tissues was the th of the vertebral body lying posterior he stomach; in other words, the depth ıe first or second lumbar vertebral body een in the lateral projection (Fig. 3).

luid in the stomach sufficient to dam ts distal portion makes the interpreta- of the film more difficult and may eas-:ead to errors (Fig. 4). It is only with ctice and evaluation of the patient whole (especially the body build) that :roximate normal standards may be ;ved. Holm (6) reviewed some 449 :s and found that (1) obesity (Fig. 6) (2) ascites (Fig. 5) produced an in-se in the thickness of the retrogastric ıes which simulated pancreatic en-ement. He also lists other conditions :h may produce anterior displacement ıe stomach: (1) tumors of the liver, (2) ıstatic nodes, (3) infiltration of the pan-s due to perforated ulcer, (4) hyper-roma and retroperitoneal neoplasms. n's work does not point out that, al-gh these conditions do produce an in-se in the retrogastric space, actual reatic disease produces a clear-cut ap-ınce (Figs. 7, 8, and 9)—so clear-cut we have had no difficulty in those in which the disease lay wholly in the reas. The enlargement may be due to nmatory, cystic, or neoplastic change. errors in interpretation have been in those cases in which fluid or a fat pad widened the retrogastric space and simulated pancreatic enlargement (Figs. 5 and 6).

Holm also reported the diagnosis of atrophy of the pancreas by a marked decrease in the retrogastric tissues, but we have not seen any such cases.

SUMMARY AND CONCLUSIONS

A simplified technic for gastric pneumography is presented, and the interpretation of normal and abnormal findings is discussed.

Gastric pneumograms are of definite supplementary diagnostic value in the location and diagnosis of enlargement in the body and tail of the pancreas (both benign and malignant) and of aid in the localization of certain epigastric masses.

NOTE: On page 204 of this issue of RADIOLOGY is an abstract of a paper, from the surgeon's point of view, including ten case reports which were reviewed at the time this communication on the roentgen aspects was written.

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Rapid Development of Bone Changes in a Patient with Syringomyelia as Observed Roentgenologi

EUGENE P. PENDERGRASS, M.D., GEORGE D. GAMMON, M.D., and LT. JAMES H. POWELL, M.C.,

We have had under observation a patient with syringomyelia, who within a few weeks developed marked bone changes in several joints. This case is being reported to illustrate the rapidity with which these changes may occur and to emphasize, among other things, their importance in neuropathic joints because of the medicolegal and compensation aspects.

CASE REPORT

O. H., a 44-year-old Negro, was referred for a roentgen examination of a painful left shoulder on Feb. 17, 1942. A diagnosis of subdeltoid bursitis had been made in the surgical outpatient department and novocain injections had been given to relieve the pain. The roentgen examination showed nothing abnormal (Fig. 1).

A month later (March 16, 1942) the patient returned to the surgical outpatient department because of an elevation of temperature, ranging to 102°. The shoulder ached and was swollen and fluctuant. It could be dislocated downward and posteriorly and the dislocation could be reduced without pain. Aspiration yielded about 50 c.c. of serosanguineous fluid. Smears and cultures were negative. A roentgen examination, March 24, showed considerable destruction of the head of the humerus, and a diagnosis of a neuroarthropathy was made (Figs. 2 and 3). Up until this time the previous history of the patient was entirely unknown to members of the department of roentgenology.

A request was made for an examination of other parts of the body. The only other abnormal joints observed were the right and left elbows, which showed beginning absorption of cartilage and some hypertrophic changes (Figs. 4 and 5).

The patient was an alum packer and had been admitted to the neurology clinic in 1927, complaining of soreness and numbness in his left hand, especially along the distribution of the ulnar nerve. In the next three years his symptoms progressed. The left pupil was larger than the right. Serologic tests of the blood and spinal fluid were negative. By 1940, a limp and weakness of the left knee had developed. Amputation of the right middle finger was done for a non-healing ulcer. Serologic tests were again negative.

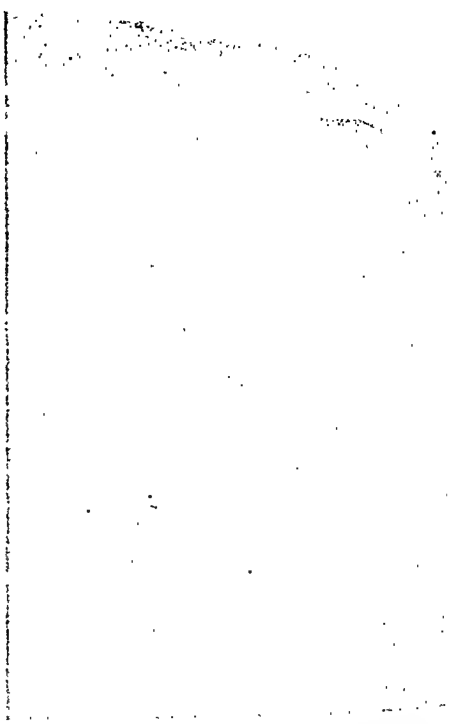

Fig. 1. Roentgenogram of left shoulder, 17, 1942, showing nothing abnormal; no evidence of bursitis.

In December 1941, the reflexes were r follows:

Biceps
- Right: Markedly depressed
- Left: Markedly depressed

Triceps
- Right: Markedly depressed
- Left: Markedly depressed

Abdominals
- Right: Absent
- Left: Absent

Cremasteric
- Right: Exaggerated
- Left: Exaggerated

Patella
- Right: Exaggerated
- Left: Greatly exaggerated

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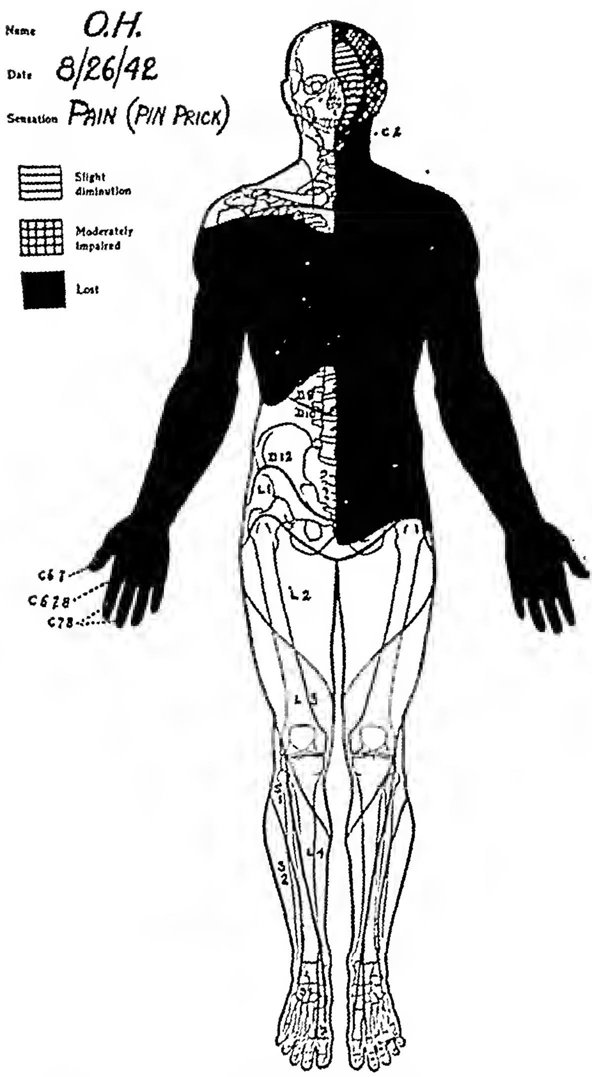
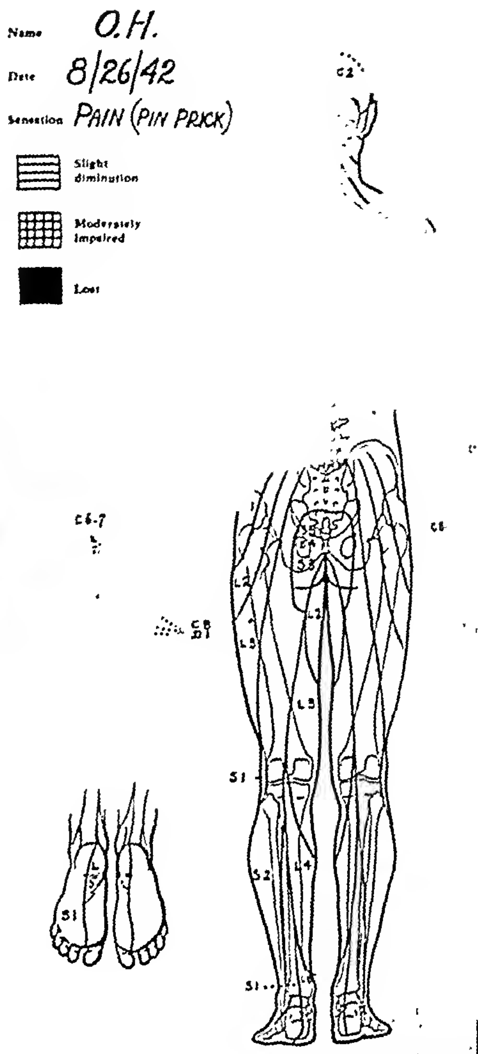
[1] From the Departments of Radiology and Neurology in the Hospital of the University of Pennsylva delphia, Penna. Accepted for publication in December 1944.

gs. 2 and 3. Roentgenograms in internal (Fig. 2) and external (Fig. 3) rotation, made March 24, 1942, ap-imately five weeks after the original examination (Fig. 1). The head of the humerus is completely destroyed there is considerable bony debris in the joint. The glenoid fossa of the scapula is also involved. Many studies : been made of this shoulder over a two-year period and the bone destruction has increased only slightly.

s. 4 and 5. The left elbow (Fig. 4) shows evidence of cartilage destruction, especially on the external condyle :: humerus. There are loose fragments of bone in the soft tissues and a peculiar overgrowth of the lateral t of the head of the radius. Changes in the right elbow (Fig. 5) are less marked than in the left. In the .l view bone fragments are seen in the soft tissues.





Figs. 6 and 7. Diagrams of loss of pain sensation on the anterior and posterior aspects of the body, Aug. 2

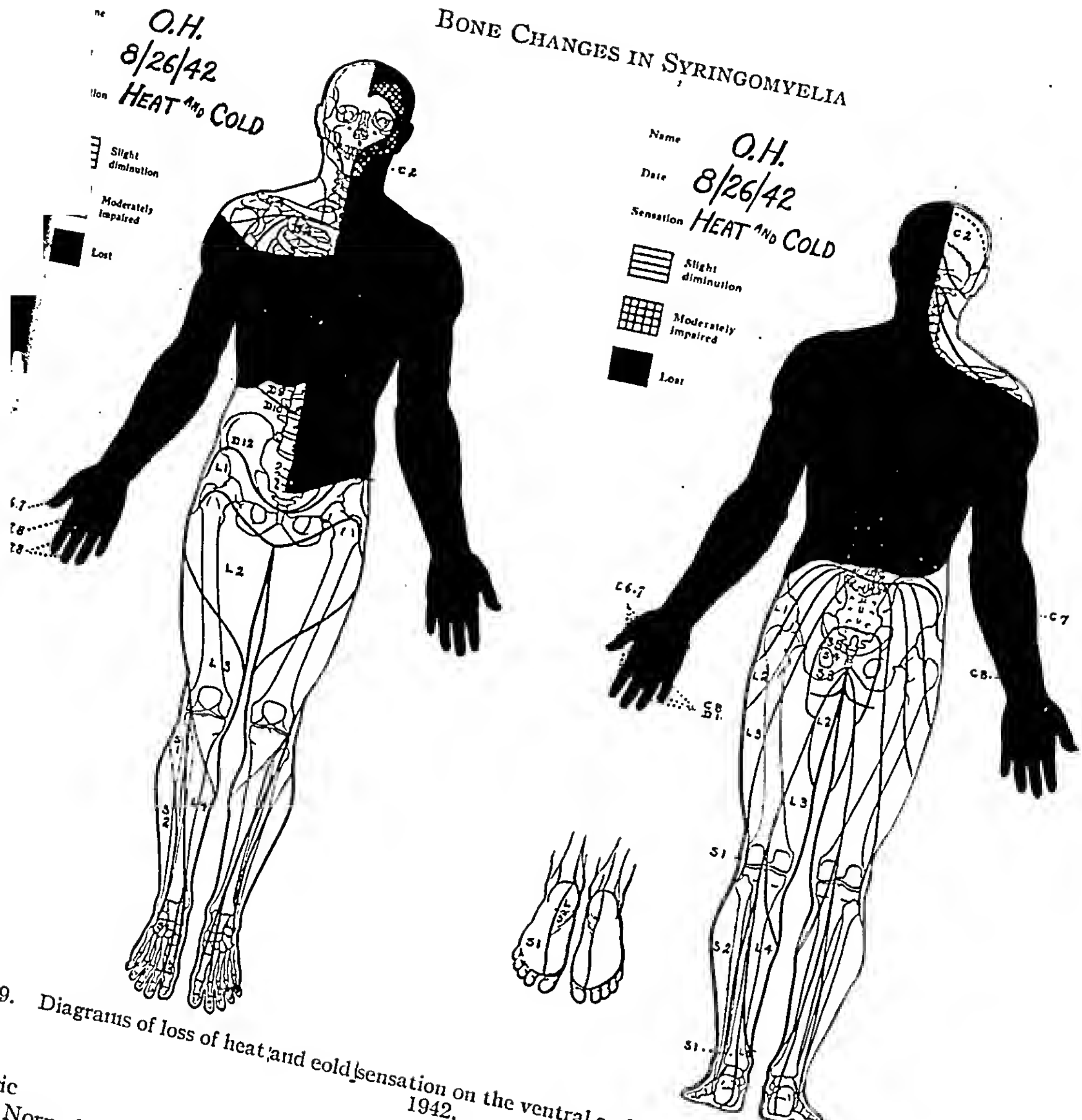
Achilles
  Right: Exaggerated
  Left: Greatly exaggerated
Babinski
  Right: Negative
  Left: Negative
Patella clonus
  Right: Present
  Left: Sustained
Ankle clonus
  Right: Sustained
  Left: Sustained

Serologic tests of the blood and spinal fluid were still negative. The colloidal gold curve was flat.

After the roentgen diagnosis, another effort was made to determine the cause of the patient's illness. A provocative test for syphilis was started on June 30, 1942, and continued for one month. Repeated serologic tests were negative.

In August 1942, the physical examination revealed scoliosis of the lumbar spine with the convexity to the left; shortening of the left arm, with decre- tone of all of the muscles of the arm; slight w- of the rhomboideus, supraspinatus, and infra- muscles of the left shoulder girdle, with no muscular atrophy. Muscular weakness was served in all extremities, more noticeable on the especially in the left hand. The gait was spastic left leg exhibiting the greater spasticity. Re- test negative. Reflexes as follows:

Biceps
  Right: Absent
  Left: Absent
Triceps
  Right: Barely perceptible
  Left: Absent
Supinators
  Right: Absent
  Left: Absent
Abdominal (upper and lower)
  Right: Weak
  Left: Absent



;s. 8 and 9. Diagrams of loss of heat and cold sensation on the ventral and dorsal aspects of the body, Aug. 26, 1942.

:remasteric
  Right: Normal
  Left: Absent
:nee jerk
  Right: Exaggerated
  Left: Spontaneous clonus
ankle jerk
  Right: Exaggerated
  Left: Greatly exaggerated
'atella clonus
  Right: Sustained
  Left: Markedly sustained
ankle clonus
  Right: Sustained
  Left: Markedly sustained
Babinski
  Right: Negative
  Left: Positive

'here were diminution of pain sensation over the trigeminal area, loss of pain sensation with pres-ervation of touch from segment C_2 to T_{12} on the left, and similar findings on the right from segment C_5 to T_{10}. Sensation of heat and cold was lost over essentially the same areas as pain (Figs. 6–9). Vibratory sense, sense of position, graphesthesia, light and heavy touch sensation were all normal.

Cranial nerve examination showed no involvement of the olfactory sense. Visual fields and retinae were normal. There was no ptosis of the lids. The left pupil was larger than the right and reacted sluggishly to light. There was rotatory nystagmus on left lateral gaze. The left corneal reflex was barely perceptible. Sweating was much more profuse on the right side of the face. There was sensory diminution, as noted above, over the left trigeminal area. The patient was slightly hoarse, but direct laryngoscopy failed to reveal any abnormal cord changes or evidence of paralysis.

Spinal tap yielded a clear fluid under a pressure of 170 mm. water, with 4 white blood cells per cubic millimeter, 25 mg. per cent protein, a negative Wassermann reaction, and a colloidal gold curve of

whenever they encounter a Charcot joint, to obtain a careful history concerning trauma and time of development of the joint changes.

Our case of syringomyelia and some of those reported point to the necessity of obtaining past medical histories and neurologic examinations even in patients who have presumptive conditions such as subdeltoid bursitis, fracture, or bone tumors. Destructive changes may in many instances, in certain joints, develop more rapidly than is commonly suspected.

SUMMARY

A case of syringomyelia, with the development of extensive changes in the scapula and humerus of the left shoulder, is reported.

The changes appeared within three weeks after an injection of novocain into the tissues for the relief of pain thought on preliminary examination to be due to a subdeltoid bursitis.

Some of the literature reviewed indicates that severe trauma or minor injuries often repeated may result in the rapid development of neuroarthropathies.

Reports are available suggesting that injuries occurring prior to the development of neuropathic joints may have medicolegal and compensation importance.

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Unusual Pleural Effusions[1]

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IE TYPICAL roentgenogram in cases of pleural effusion is quite familiar. efly, the effusion in the absence of umothorax first produces a uniformly ise opacity obliterating the costophrenic le. The medial border is crescentic and ends downward and inward toward the phragm. As the effusion increases, it ends medially over the diaphragm and vard along the lateral aspect of the st. The free margin is concave and density is higher in the lateral or costal tion of the thorax than in the medial. the absence of a fixed mediastinum, e pleural effusions cause displacement he mediastinal contents to the opposite .

he upper concave margin seen in the ntgenogram does not, however, represent the actual height of the fluid. Kau- (1, 5) has demonstrated that simple ıral effusions may be divided into three ons. The lowest and most radiopaque e is made up almost entirely of fluid, middle or translucent area is due to a derate amount of fluid, slightly comssing the lung, and the uppermost area ansparent but represents a film of fluid is too thin to be seen in the x-ray film. mall collections of fluid may not be in the conventional upright posteroerior roentgenogram, the effusion being len in the posterior and anterior ophrenic sulci by the liver and the hragm. Thus Kaunitz (1) injected c.c. of normal saline into the pleural ty of an adult and was unable to obtain adow in the lateral costophrenic angle. Ganter (2) has shown that less than 400 c.c. of pleural fluid cannot be demonstrated by physical examination or the ordinary chest film. This fact serves to emphasize the necessity for altering the usual methods of roentgen diagnosis to detect small pleural effusions. This has been ably done by Rigler (3, 4), who showed that all pleural transudates and most pleural exudates, especially those of recent origin and nonpurulent character, shift markedly as the position of the patient is changed. By placing the patient in a variety of positions for roentgenographic study, one can take advantage of this fact to detect small pleural effusions and differentiate thickened pleura from fluid. Thus, when a small pleural effusion is suspected because of clouding of the costophrenic sinus, a postero-anterior roentgenogram with the patient in the lateral decubitus position will often disclose a dense or hazy shadow occupying the inferior costal gutter, which in this position is the most dependent portion. This position, therefore, will often reveal the presence of fluid that is concealed by the liver and diaphragm when the patient is erect. When the patient is supine, the characteristic appearance of fluid is no longer present but the involved hemithorax becomes cloudy instead. The use of the Trendelenburg position is also of value, for in this position the pleural fluid shifts to the upper part of the hemithorax, permitting visualization of the part of the lung which is obscured by the fluid when the patient is upright. When no change in the position of the fluid is seen, it is

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Figs. 5 and 6. Pleurisy with effusion, in which the upper border of the effusion is convex and simulates elevated diaphragm. The arrow points to an accumulation of fluid in the right superior paramediastinal sp- resembling an enlarged ascending aorta. Figure 6 shows the appearance after the removal of the fluid. N also, that the shadow in the paramediastinal space is no longer present.

Figs. 7 and 8. Left pleural effusion with convex upper border. Figure 8 shows the appearance after the re- of the pleural fluid. There continues to be a pleural reaction above the left leaflet of the diaphragm.

this density represents a pleural reaction, fluid, or possibly pulmonary compression. Figure 8, taken after the removal of 300 c.c. of clear amber fluid, continues to show a pleural reaction above the left diaphragm.

In our experience, the most comm atypical pleural effusion is that in wh the fluid accumulates in the paramed- tinal pleural space. The collection fluid is localized between the pari-

leura, which forms the lateral boundary f the mediastinum, and the adjacent isceral pleura. Above the root of the ing the paramediastinal pleural space xtends uninterruptedly from the sternum o the vertebral column, while below the oot of the lung the pulmonary ligament, hich extends from the hilum to the diaaragm, divides the space into an anterior nd posterior division. Figure 9 shows iagrammatically the most common forms paramediastinal pleural effusions. An nterior paramediastinal pleural effusion seen roentgenographically as an opacity ving a well defined margin parallel with e right or the left border of the heart, ving the impression that the cardiac mar- n is reduplicated. This type of pleural usion is often described as ribbonaped. The cardiophrenic angle may or ay not contain fluid. Figure 10 shows e appearance of an anterior paramediasal pleural effusion on the left suggesting increase in the transverse diameter of e heart. After removal of 1,500 c.c. of ar fluid the actual size of the heart can seen (Fig. 11). The volume of fluid in such paramediastinal pleural effusions is often surprisingly large. Figure 12 shows a right anterior paramediastinal pleural effusion. The large rounded mass

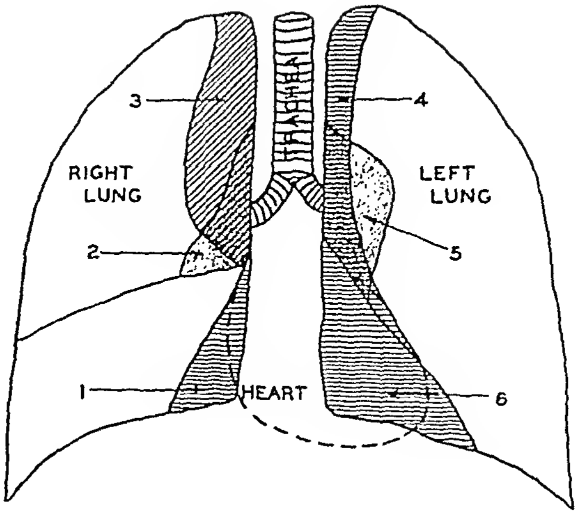
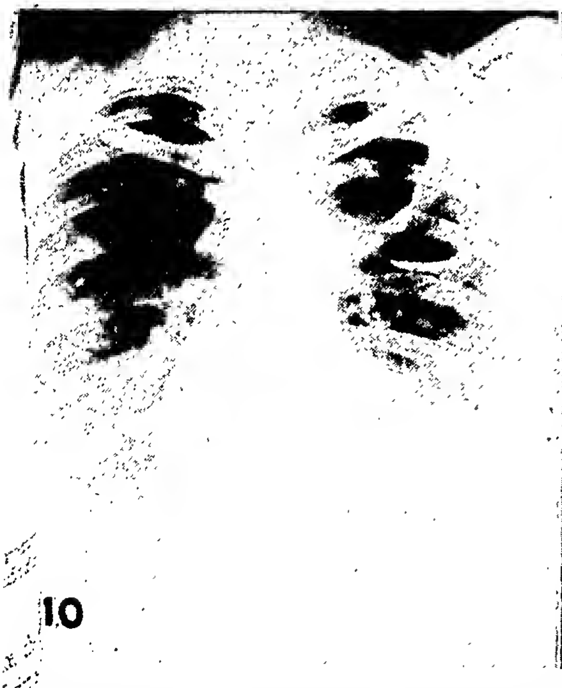
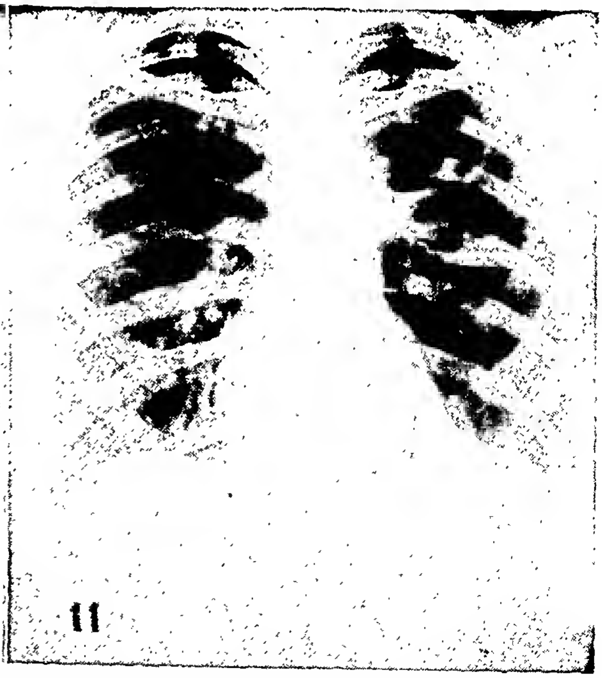


Fig. 9. Diagrammatic representation of the most common forms of paramediastinal pleural effusions (adapted from Harvey, 11). 1. Right inferior paramediastinal effusion. 2. Right parahilar paramediastinal pleural effusion. 3. Right superior paramediastinal pleural effusion. 4. Left superior paramediastinal pleural effusion. 5. Left parahilar paramediastinal pleural effusion. 6. Left inferior paramediastinal pleural effusion.





s. 10 and 11. Anterior paramediastinal pleural effusion on the left, suggesting an increase in the transdiameter of the heart. There is also extensive cavitation in the left upper lobe. Figure 11 was made after moval of 1,500 c.c. of fluid. The actual size of the heart can be seen.

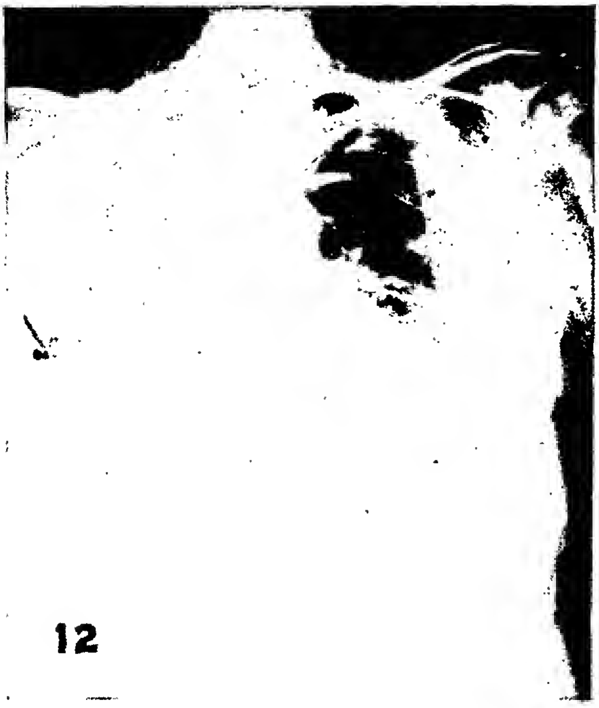


Fig. 12. The arrow points to a large round mass continuous with the heart shadow, resembling right-sided cardiac enlargement, but actually representing a right anterior paramediastinal pleural effusion.

continuous with the heart shadow resembles an enlarged right auricle. The physical signs in this type of effusion are located anteriorly. Dullness continuous with that of the heart is usually present, and over the area of dullness the usual signs of pleural effusion are in evidence.

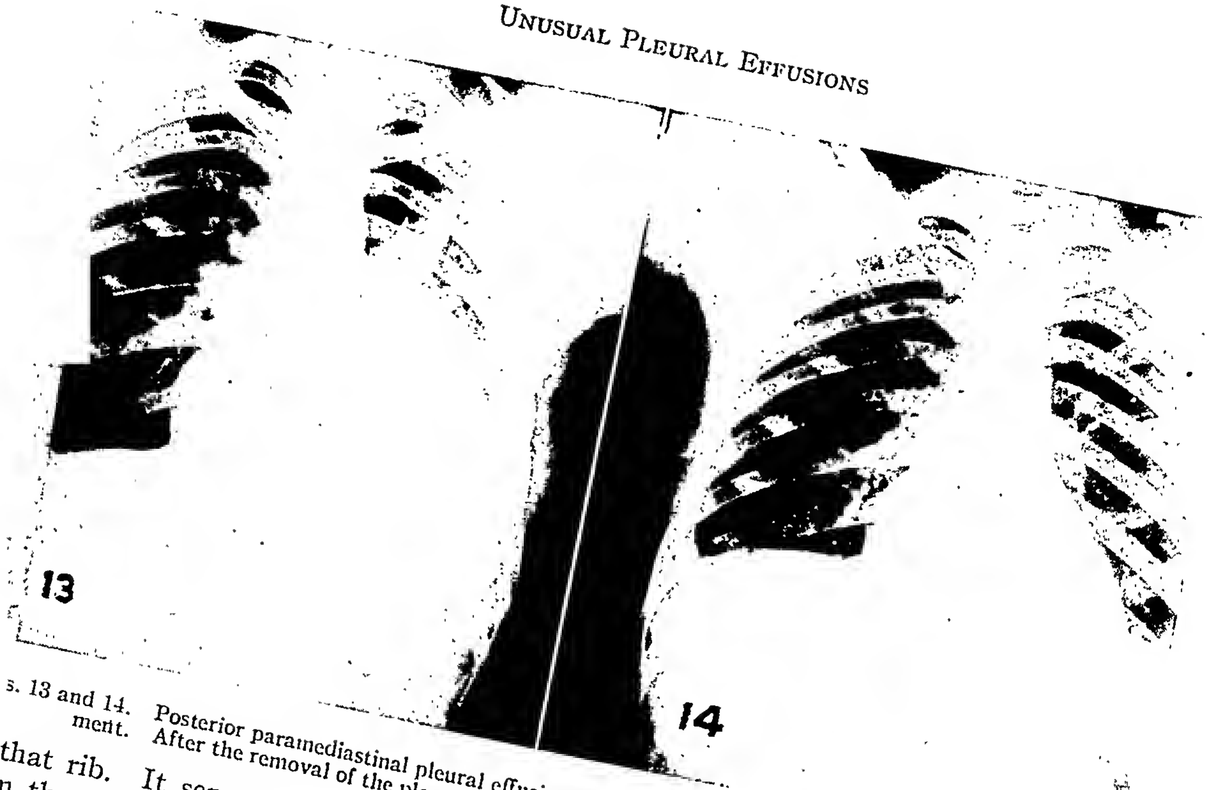
Posterior paramediastinal pleural effusions present ribbon-shaped shadows running parallel to the right or left borders of the vertebral column or triangular opacities with the base resting upon the diaphragm and the apex of the triangle directed toward the hilum. The case shown in Figure 13 was referred to the hospital because it was believed that the heart had enlarged rapidly over a six-day period. It represents a posterior paramediastinal pleural effusion which cannot be distinguished from the heart shadow. However, fluoroscopic examination and oblique views showed that the effusion could be readily projected away from the heart shadow. After removal of the pleural fluid, the true size of the heart could be seen (Fig. 14). Physical signs may be absent, but when the effusion extends to the chest wall, the signs of pleural effusion are present late[ral] to the vertebral column.

In Figure 5 the arrow points to a coll[ec]tion of fluid in the paramediastinal ple[ural] space, extending above the root of [the] lung. This shadow simulates a mediasti[nal] tumor or an enlarged ascending aor[ta]. After the removal of the fluid, this shad[ow] is no longer present (Fig. 6).

In most cases the heart and adja[cent] paramediastinal pleural fluid are of di[ffer]ent densities and therefore readily dis[tin]guishable (Figs. 15 and 16). At tim[es], however, the pleural fluid and heart [are] almost identically opaque and it may [be] difficult to determine where the lat[eral] border of the heart ends and the ple[ural] effusion begins. It is this latter typ[e of] effusion that so closely simulates car[diac] enlargement or encapsulated pericar[dial] effusion (Figs. 10, 12, and 13). Obl[ique] and lateral views combined with a flu[oro]scopic examination will readily disclose [the] true nature of the pathological proces[s].

In all of our cases the paramediasti[nal] pleural effusions were of tuberculous or[igin]. Any of the many causes of pleural effus[ion] may, however, result in an accumulatio[n of] fluid in the paramediastinal pleural cav[ity].

Clinical recognition of fluid in the in[ter]lobar spaces is difficult. A thoro[ugh] knowledge of the anatomical location [and] roentgenological appearance of the in[ter]lobar fissures is important in the ev[alua]tion of this type of effusion. Briefly[, the] left lung is divided into an upper [and] lower lobe by a long fissure which be[gins] posteriorly some 6 cm. below the ap[ex of] the lung at about the level of the vert[ebral] end of the fourth rib and extends oblig[uely] downward and forward, ending ante[riorly] at the costochondral articulation of the s[ixth] rib, which is near the cardiac apex. On [the] right, the long fissure is similar in posi[tion] to the long fissure of the left lung be[ing] slightly more vertical. It separates [the] lower lobe from the middle and u[pper] lobes. The short fissure begins in the [long] fissure in the axillary region at the lev[el of] the fourth rib and extends horizont[ally] forward to the costochondral articula[tion]



s. 13 and 14. Posterior paramediastinal pleural effusion on the left, giving the impression of cardiac enlarge-ment. After the removal of the pleural fluid (Fig. 14) the true size of the heart can be seen.

that rib. It separates the upper lobe m the middle lobe. These fissures ex- d to the hilum of the lung.

We are not considering here encapsu- ed interlobar effusions that remain con- ed to the interlobar space regardless of effect of gravity, but rather fluid that ree in the general pleural cavity but ends into the interlobar fissure. At es, the presence of the effusion in the erlobar fissure can be seen only when the ient is placed in certain positions.

he short interlobar fissure is more com- ly the site of interlobar pleural effu- s than the long fissures. In Figure 17 pleural effusion occupies the costo- nic angle and extends upward along axillary border to the short interlobar re, where the narrow horizontal band esents an accumulation of fluid at this

When only a small amount of fluid is ent in the pleural cavity, it does not as high as the short fissure with the ent erect. When the horizontal po- n is assumed, however, the fluid es a higher point and may be drawn one of the interlobar fissures by the of capillarity existing there. This is nore likely to occur in the lateral de- cubitus position, in which instance the fluid occupies the inferior costal gutter and readily enters one of the interlobar spaces. When the effusion is large enough, as in the case seen in Figure 17, the fluid reaches and enters the interlobar fissure even when the patient is upright. In this event the interlobar effusion becomes considerably wider and even ovoid in the horizontal or lateral decubitus position (8).

The x-ray appearance of the interlobar portion of the pleural effusion is determined by the course of the interlobar fissure (Figs. 17 and 18). In any event, the den- sity is horizontal, vertical, or oblique; it extends from the hilum, and appears at different levels of the lung fields depending upon the part of the fissure involved. The size and shape of the interlobar effusion vary according to the volume of the fluid and the compressibility of the adjacent lobes (8). The smaller interlobar effu- sions are narrow and band-shaped, whereas the larger ones are ovoid or circular. In the lateral position the shadows have clearly defined upper and lower borders which are either straight or convex.

This type of interlobar effusion is most commonly of tuberculous or pneumonitic

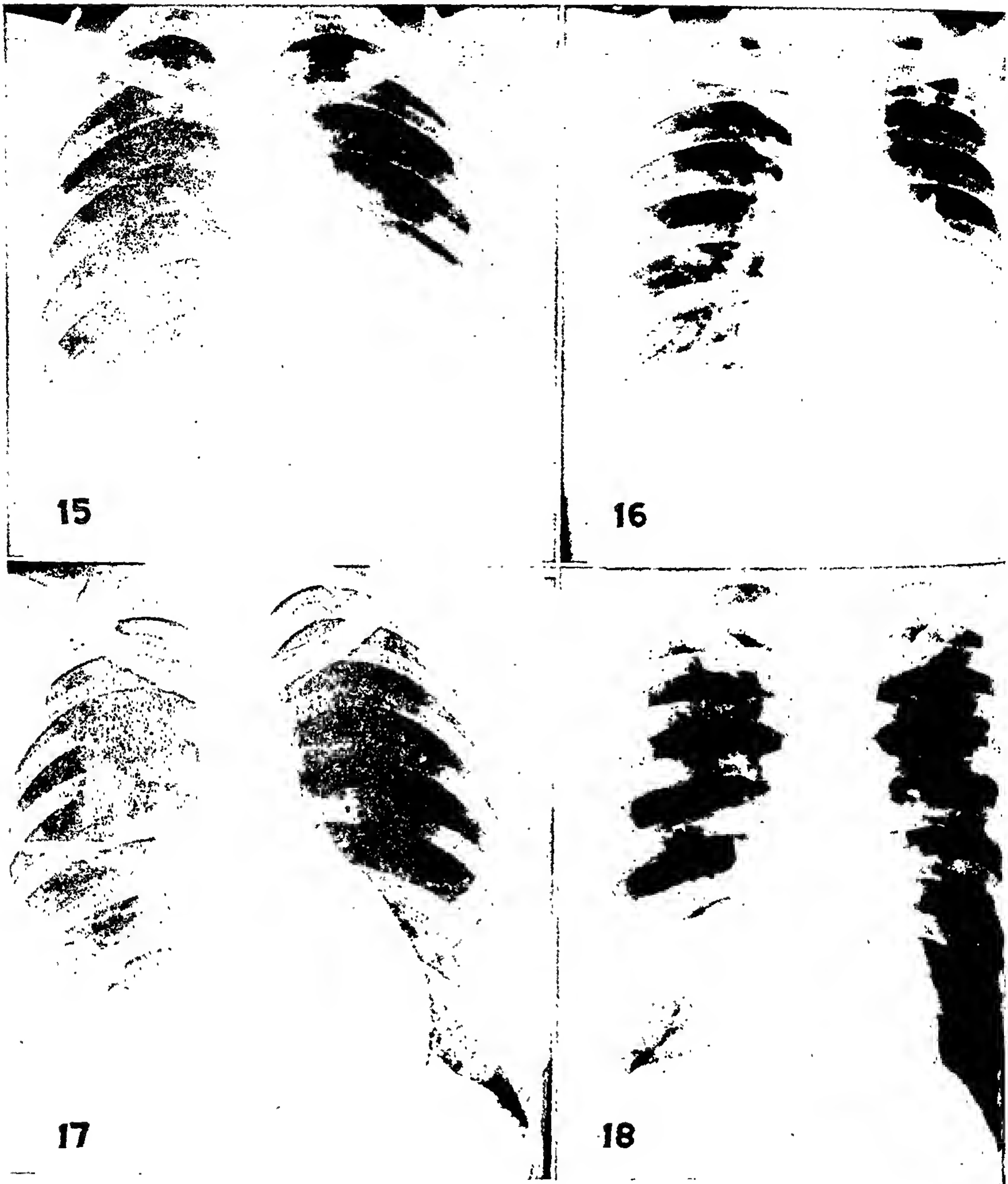


Fig. 15. Ribbon-shaped shadow along the left border of the heart, representing a paramediastinal pleural e... The heart and paramediastinal pleural effusion are of different densities and therefore readily distinguish...
Fig. 16. Pleural effusion obliterating the left costophrenic angle and extending along the left border of th... in the left paramediastinal pleural space.
Fig. 17. Pleural effusion occupying the right costophrenic angle and extending upward along the axillary... to the short interlobar fissure, where the narrow horizontal band represents an accumulation of fluid at th...
Fig. 18. Pleural effusion occupying the right costophrenic angle and extending into the interlobar fissure be... the lower and middle lobes.

origin but may be seen occasionally in cases of congestive heart failure.

Many reasons are offered for the unusual appearance of atypical pleural effusions. Surely, any factor altering the retractility of the lung will affect the contour of the pleural fluid. Thus, pulmonary fibrosis, consolidation, or edema, by reducing... retractile power of the lung, allows gra... to exert the greatest influence, and th... fore the fluid level may not be concave... Changes in the character of the pleura... duced by inflammation or adhesions... affect the shape of the fluid consider...

literation of portions of the pleural ity may determine the localization of ural effusion. In the interesting case pleural effusion simulating elevation of diaphragm reported by Yater and dis (9), a satisfactory explanation for unusual appearance of the tuberculous ural effusion was not obtained from the ropsy. It was concluded that the d was encapsulated above the diaagm by thin fibrinous adhesions but aped rather freely as the position of the ient was changed. The effect of adhes on the contour of pleural effusions considerable. Pleural adhesions fortuisly situated may confine fluid in a nge way.

Korol and Scott (10) have attempted to lain the convex upper border occaally seen with pleural effusions on basis of a hydropneumothorax, with air pocket obscured by a partly exded and adherent lung. They state t the lateral decubitus position with patient lying on the normal side will nonstrate the concealed air bubble ve the fluid level. While this explana may occasionally obtain, it is not sfactory in most cases, for the patients ing pleural effusions of unusual type usually examined in a variety of posis, without any pneumothorax being nonstrated. Furthermore, in our cases e was no evidence of spontaneous umothorax nor was the accidental in-uction of air into the pleural cavity ible, since thoracentesis had not been ormed before the x-ray films were e.

lthough there are numerous factors which influence the variation in appearance of pleural effusions, it must be admitted that in many cases no satisfactory explanation is apparent.

SUMMARY

A review of the cases that have been presented demonstrates the unusual positions and contours that may be assumed by pleural effusions, as well as the diagnostic confusion that may arise. It is to be emphasized that fluoroscopic and roentgenographic examinations in a variety of positions are mandatory for proper evaluation of the process.

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Radon Ointment Treatment of Irradiation Ulcers[1]

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LARGE IRRADIATION ulcers with accompanying necrosis, infection, and sloughing, and often eventual malignant changes, have long been a serious therapeutic problem. Treatments designed for ordinary deep burns are not effective; the ulceration produced by atrophy of the skin and vascular obliteration is extremely indolent. Probably the only effective treatment has been excision and skin grafting. Because of the usual infection and malignant changes, along with the reduced blood supply, satisfactory results have not been frequent.

Fortunately, fewer of these extensive ulcerations are now seen than formerly. Better understanding of the biologic effects of irradiation and the more accurate determination of dosage have contributed to this improvement. The tissues of some patients, however, prove abnormally sensitive to roentgen and gamma rays. Furthermore, to arrest many deep-seated cancers, irradiation has to be pushed to the limits of tissue tolerance. Instances of slowly developing, severe injuries from irradiation given many years ago are seen frequently enough to make the problem an urgent one.

Since 1930, Uhlmann (5) has advocated the application of petrolatum impregnated with radon. He has expressed the belief that the mechanism involved is the superficial effect of alpha particles, previously never used therapeutically. In ordinary radium therapy, radium or its decay products are always enclosed in glass or metal, or both, preventing the egress of alpha radiation. Although there seems to be no logical reason to employ radon to treat an injury produced by radium or roentgen rays, yet radon absorbed in petrolat[um is] a rich source of a type of radiation—[alpha] particles—not involved in the produ[ction] of these injuries.

We have treated two patients, the [first] two to receive this form of therapy [at the] Mayo Clinic. In each case the con[dition] was unusual; ulceration of many y[ears'] standing had undergone malignant c[hange] and all methods of treatment hitherto [tried] had been employed without avail. [The] patients were treated by the applic[ation of] petrolatum that contained radon, i[n an] attempt to heal the ulcers, and by [...] filtered radium to control the malig[nant] changes.

REPORT OF CASES

CASE 1: A girl, aged eighteen years, first reg[istered] at the clinic in 1919 with an open draining w[ound in] the right lower quadrant of the abdomen. [She] stated that in November 1917, because of sever[e pain] in the right lower abdominal quadrant, app[endec]tomy had been performed with removal of a [...] appendix. A few months later, the wound [broke] down and remained open and draining. At a[nother] operation, performed in April 1919, necrotic [tissue] was excised, but closure of the wound w[as not] achieved. Low-voltage roentgen treatment [had] been given in an effort to obtain healing [...] seemed to relieve pain, but complete healing [did not] occur. The patient exhibited a large ele[ment of] hysteria, and it was thought that the wound [was] kept open by her interference. A diagn[osis of] traumatic ulceration and hysteria was made.

In September 1926, the patient returned. S[he had] married during the previous month. The [wound] was still open and draining in spite of radium t[reat]ment which, she said, she had received three [...] previously. She had been taking large doses of [mor]phine during the past five years.

In 1930, the ulcer had temporarily healed e[xcept] for scabbing, and the morphinism had been [con]trolled.

The patient's next visit was in November [...] A large draining ulcer was present over McB[urney's ...]

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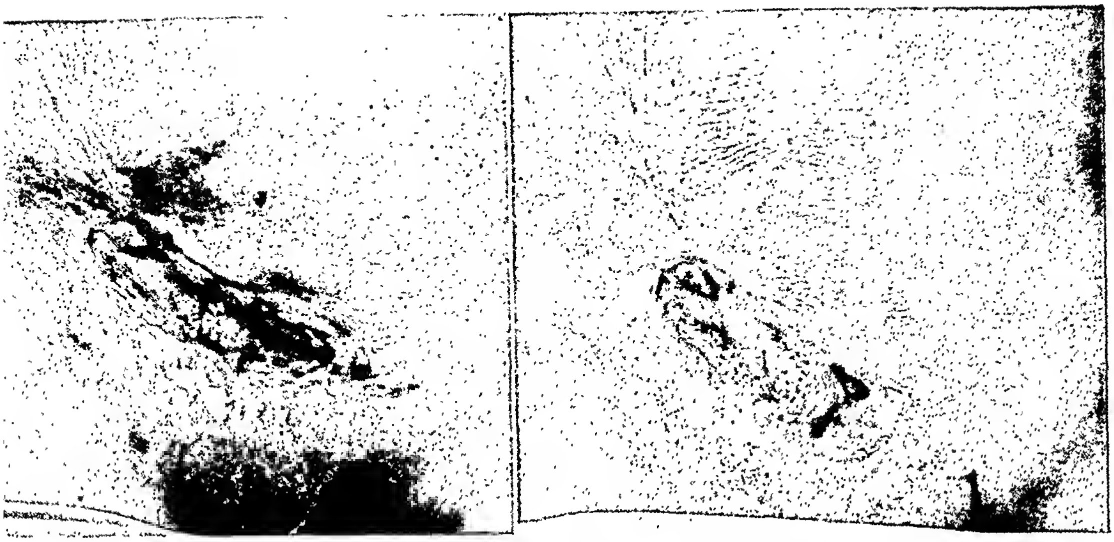
[1] Presented at the Joint Meeting of the American Roentgen Ray Society and the Radiological Society of North America, Chicago, Ill., Sept. 24–29, 1944.



1 and 2. Traumatic ulcer with irradiation damage, before treatment with radon in petrolatum (December 1943) and after one course of radon ointment (March 1944). Clinically carcinoma was present.

n. Biopsy showed inflammatory tissue with elial hyperplasia. The condition was regarded aumatic and factitial dermatitis with probable iation injury superimposed.

spite of the negative biopsy, the clinical diag- was low-grade carcinoma with metastasis, l on the appearance of the ulcer and the presence arged nodes in the inguinal and femoral regions. ılcer was deep and measured 9 × 3 cm. Its base ıecrotic, with a foul discharge; the edge was l and indurated, with infiltration extending into urrounding skin. Conservative treatment with sium permanganate dressings was prescribed. the patient's return in September 1943, the still drained freely. The odor was character- of a malignant neoplasm and the nodes in both s had enlarged and become fixed. The right al nodes were also involved. Radium treat- to the metastatic nodes was administered at isit.

December 1943, the inguinal nodes were un- ged, and enlarged femoral nodes made walking ılt. Radium treatment of the nodes was again d out.

abdominal ulcer was painful and draining 1). Radon ointment therapy was employed a week for nine weeks. The ointment was y prepared in our physics laboratory. The ap- ions varied in strength from 0.031 to 0.05 mc. on per cubic centimeter of petrolatum, averag- 04 mc. per cubic centimeter; approximately was applied at each dressing. The pain with the second or third application and ge diminished.

March 1944, the malignant infiltration had through the suprapubic region and the upper f the vulva; therefore, further radium treat- was applied to these areas at that time and in June.

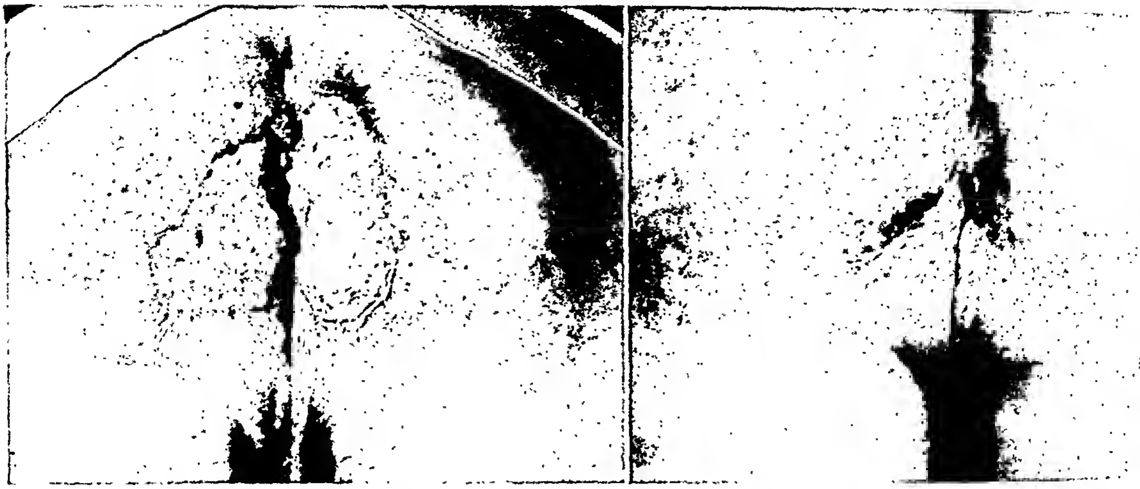
During July and August, a second series of weekly applications of radon ointment was given, the strength of the ointment varying from 0.08 to 0.10 mc. of radon per cubic centimeter of petrolatum.

Figure 2 shows some improvement. The ulcer measures 7.5 × 3 cm. and is decidedly shallower than before. Formation of epithelium has occurred along the top and sides. At this time there was no pain whatever and less drainage than before.

CASE 2: In December 1942, a man of seventy-three years registered at the clinic. Besides prostatic hypertrophy and mild diabetes mellitus, his main complaint was a large perianal ulcerated tumor, which had been present for many months. He stated that he had been given roentgen therapy in 1925 for anal pruritus, which had healed perfectly under treatment. By 1930, a reddened area appeared just above the anus, which became indurated in 1933. By 1936, he noted scaling and increasing soreness, and gradually the induration spread until it almost completely covered the anus and produced difficulty with defecation.

Examination showed an indurated, ulcerated lesion, measuring 2 × 3 cm., in the posterior margin of the anus externally, with a large area of actinodermatitis extending over both buttocks. Many lotions had been applied without improvement.

In December 1942, transurethral prostatic resection was performed, and in February 1943, an attempt was made to cure the perianal lesion by surgery. Palliative excision of the ulcerated lesion was performed and tissue was taken for biopsy from three widely separated parts of the ulcer; all these biopsies showed squamous-cell epithelioma, grade 2 (Broders). Removal of most of the neoplastic tissue was carried out, but some of it could not be removed because complete excision would involve cutting into the rectal wall. The malignant ulcer was heavily treated with radium in March



Figs. 3 and 4. Perianal lesion before application of radon ointment (July 21, 1943) and after application of ointment (May 19, 1944).

1943. This treatment has served to arrest the malignant lesion to date. However, the large open ulcer, as painful as the previous lesion, remained.

Many therapeutic measures were employed in the attempt to heal this huge roentgen ulcer. Extract of Aloe vera was applied, as well as ointments containing gramicidin, sulfonamide compounds, and aluminum acetate washes. Improvement did not follow any of these measures.

Radon ointment therapy was started July 27, 1943, and was continued once a week through Oct. 19, thirteen treatments in all. The dose ranged from 0.03 mc. to 0.07 mc. per cubic centimeter of petrolatum, with an average of 0.05 mc. per cubic centimeter. Approximately 12 c.c. of petrolatum was used at each application.

The original lesion is shown in Figure 3, the photograph having been taken July 21, 1943. The patient felt more comfortable after the first two or three applications than he had felt before, and a gradual clearing up of the sloughing, indolent lesion became evident. Eventually, complete epithelization occurred, as shown in Figure 4, a photograph taken May 19, 1944. Pain has disappeared completely and the patient is now able to walk, to lie on his back, and even to sit down with some comfort.

HYPOTHESES REGARDING THE EFFECTS OF RADON OINTMENT

Four possibilities are suggested to explain how the radon in petrolatum produces a beneficial effect on the tissue. These are as follows: (1) the action of the radiations on the tissue itself; (2) the action of the radiations on the petrolatum; (3) the simultaneous action of the irradiations and the petrolatum; (4) the action of the disintegration products of radon on tissue.

Action of Radiations on the Tissue: T[illegible] tissue dose from gamma and beta radia[illegible] is probably too small to have any sig[illegible] cant effect. The dose from the alpha r[illegible] ation would be very great but would [illegible] confined to the tissue within a radiu[illegible] about 0.1 mm. of the disintegrating ra[illegible] active atoms. If any beneficial eff[illegible] are produced because of alpha irradiati[illegible] then it is essential that the ointment c[illegible] into contact with the tissue so that th[illegible] pha particles can penetrate into it. T[illegible] depth of tissue affected is undoubtedly [illegible] creased because of penetration of petr[illegible] tum containing radioactive atoms [illegible] by absorption of radon by the ti[illegible] There is also the possibility of a bene[illegible] effect being produced as a result of th[illegible] radiation of the tissue fluids as well as [illegible] cells.

Although it generally has been th[illegible] that any of the common types of radi[illegible] is harmful rather than beneficial to i[illegible] ation injuries, little is known about e[illegible] produced by alpha radiation. It has [illegible] assumed that its action, except for the [illegible] that it is very concentrated, is essent[illegible] the same as that of other typ[illegible] radiation. This greater concentra[illegible] of absorbed energy may start a serie[illegible] biologic reactions which differ in som[illegible] spects from the series of reactions sta[illegible] by other types of radiation. Eryth[illegible] similar to that produced by roentge[illegible] gamma rays was produced by the [illegible]

ntal irradiation of the back of a hand alpha rays from a cyclotron a few years o (2), but this does not necessarily mean at all the other biologic reactions pro- iced by the radiations were similar.

Action of Radiations on Petrolatum: ne intense irradiation received by the pet- latum must produce some chemical and iysical changes, and it is possible that me of these changes might make it a more neficial therapeutic agent. A commer- il brand of petrolatum which is irradi- ed with ultraviolet rays is supposed to more beneficial for some purposes than dinary petrolatum. Stenstrom and Vig- ss (4) have shown that irradiation of avy mineral oil by roentgen, beta, and raviolet rays causes it to spread out er a larger area when it is placed on ter; a somewhat similar effect might produced by alpha radiation on petro- um. If any therapeutic effect of radon petrolatum is due to the action of the liation on the petrolatum, it might be ssible to obtain the same result by treat- petrolatum with some other types of iation before it is applied to the lesion. however, the changes produced in the rolatum were unstable, it might be essary to irradiate the petrolatum dur- application, in which circumstance al- radiation might be the radiation of ice since, because of its low penetrat- power, it would not affect deeper tissue.

Simultaneous Action of Radiations and rolatum: Irradiation produces changes tissue, such as ionization, changes in permeability, and changes in osmotic ssure, and irradiation must produce ie physical and chemical changes in rolatum. Perhaps it is a combination hese effects that is therapeutically bene- il.

ction of Disintegration Products of lon: In petrolatum containing radon e would be traces of radioactive iso- es of other elements. Until the instant these radioactive atoms disintegrate, act chemically and physiologically he same manner as non-radioactive ients. The amount of these isotopes present in each cubic centimeter of pet- rolatum would depend on the concentra- tion of the radon, and the amount of one of them (the isotope of lead, RaD) would depend, also, upon the length of time the radon had been in the petrolatum. The order of magnitude of the amounts of these radioactive isotopes in each cubic centi- meter of the petrolatum would be 10^{-10} mg. of polonium, 10^{-9} mg. of bismuth, and 10^{-7} mg. of lead. These values seem like insignificant amounts but, when expressed as number of atoms per cubic millimeter, they are, respectively, of the order of 100,- 000, 1,000,000, and 100,000,000. The presence of these isotopes in the petrolatum on the surface of the lesion would be of little importance, but if the petrolatum penetrates into the tissue, these elements might be available to the tissue; also, the radon which may be absorbed by the tissue would form these isotopes within the tissue as it disintegrated. In recent years it has been realized that traces of eelments may be of great physiologic importance (1), and the added fact that these isotopes are ra- dioactive may make it worth while to con- sider whether or not their presence is of any significance.

SUMMARY

The first two patients to be treated with radon ointment at the Mayo Clinic pre- sented about as hopeless a prognosis as could be imagined. Both were afflicted with massive ulcers of many years' dura- tion. In the first case the ulcer may have originally been traumatic, with irradia- tion damage probably superimposed. In the second case, the lesion was assuredly a roentgen ulcer. In each case, a malignant lesion had finally appeared, with distant metastasis in the first instance and local- ized cancer in the second.

In both cases, radium therapy was em- ployed to arrest the malignant lesion and radon ointment was used to treat the ulcer.

In the first case, results of radon oint- ment therapy were encouraging; evidence of healing has occurred, but further treat- ment seems necessary. In the second case,

the more prolonged treatment given has resulted in a complete healing of the ulcer.

Radon ointment therapy must be carefully distinguished from radium therapy. If the effect is due to the alpha particles, it is due to radiation of a quality not employed in radium therapy. It is known that alpha radiation is extremely powerful, and Martland (3) has condemned it as a lethal agent when radon salts are swallowed or injected into the system.

Radon ointment therapy is in an experimental stage. So far, the work of Uhlmann has shown promise. If further work continues to yield good results, we have an important adjunct to irradiation therapy. The present vogue of intensive irradiation to arrest deep-seated malignant lesions may produce many irradiation ulcers in future years. A satisfactory method of treatment of these ulcers will be a tremendous boon.

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DISCUSSION

Erich Uhlmann, M.D. (Chicago, Ill.): I am glad Dr. Fricke has had an opportunity to treat some cases of irradiation injury with radon ointment, as I have been using this for almost sixteen years, with gratifying results. As to the mechanism of the effect, I have been conducting some experimental studies, as yet unpublished. In view of these observations, I do not believe that the vaseline or petrolatum, as such, has anything to do with the effect of the ointment. It is used because of its inertness and because the amount of radiation or radon absorbed by it is large—sixteen times that of water at room temperature. [At this point Dr. Uhlmann showed slides and presented brief histories of two cases treated with radon ointment. He stressed the point that the ointment has no influence on malignant growth. In each of the two cases reported carcinoma was subsequently removed surgically.]

Lowell S. Goin, M.D. (Los Angeles, Calif.): I was anxious to say something about this paper of Dr. Fricke because in conversation and correspondence I have met with expressions of rather contemptuous doubt as to there being any sense at all to this whole procedure.

I have treated 18 cases of radiation injury with radon ointment, and I wish to say that I merely collected these cases; I didn't cause them! Results have been not 100 per cent but far better than anything I have ever seen. In fact, I have never seen a typical radiation ulcer heal under any other form of therapy. As Dr. Uhlmann says, it doesn't seem to make too much difference whether lanolin or vaseline is used as the vehicle. I have used both.

I should like to give you a brief account of one case. A young woman who had been treated for presumed malignant melanoma on the lateral aspect of the left knee had a radiation ulcer one year after treatment. The lesion was roughly circular, measuring approximately 10 cm. in diameter, exposing the head of the fibula and the lateral ligament of the knee. The knee was contracted to forty-five degrees, and the pain was so agonizing that she begged for amputation. She has received either eighteen or nineteen weekly applications of radon in lanolin. At present she has a shallow, painless, slightly ulcerated lesion about the size of the little finger nail, which is dotted with islands of epithelium. The ligaments and head of the fibula are completely covered. I cannot believe that such a result could have been obtained in any other way.

Neither Dr. Fricke in his paper nor Dr. Uhlmann in his discussion has mentioned the technic. It must be followed exactly as outlined in Dr. Uhlmann's original paper.

Lyell C. Kinney, M.D. (San Diego, Calif.): I realize, as Dr. Fricke has said, that this method of treatment is still in the experimental stage and that there are few men in the country who are using it, but such amazing results have been recorded in otherwise hopeless cases that I believe that investigation should be continued until we can properly appraise it.

A young doctor came into my office in February with a third-degree radiation dermatitis of the finger. The distal phalanges were covered with leathery skin that looked like soaked sole leather, moist and entirely free from sensation. At the proximal end was a line of demarcation. It looked as though the two distal phalanges of the finger would be lost, and the proximal phalanx was acutely inflamed and exquisitely tender.

The consultant in the case had decided to amputate the finger and, as a last resort, the chief physician in the department asked us to look at it. At the suggestion of Dr. Lowell Goin, we treated the lesion with radon ointment. Twenty applications

ʼere made, following Dr. Uhlmann's technic. I ıw the patient this last week. The skin was soft nd pliable to the very end of his finger, and there ʼas no pain or tenderness. That young surgeon is ery grateful for the conservation of his index finger, ıd I feel sure that such a result could have been ɔtained in no other way.

Robert E. Fricke, M.D. (*closing*): I wish to thank ıe discussants for their interest and for the valuable ʼntributions they have made to the subject. Dr. ·hlmann brought out a very important point; namely, that the radon ointment has no effect on malignant lesions whatever. One has to remember this and treat the malignant lesion separately whenever it is present in these ulcers.

As to what type of lesions to treat with radon ointment rather than operation, I do not think we are yet far enough advanced to make proper selections. The radon ointment therapy takes many weeks and is tedious, but surgical treatment is also a tedious matter. The important thing is, I believe, that there are now two methods of treatment, and if one fails, the other might be tried.

Capsular Osteoma of the Knee Joint. Report of Four Cases[1]

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PRIMARY TUMORS of the knee joint may derive from the meniscal or parameniscal region, from the synovial membrane and villi, from the subpatellar fat pad of Hoffa, from bursae, and from capsular or paracapsular structures. The tumors may be benign or malignant, single or multiple. They may be classified as follows:

A. Benign

1. Chondroma (single); chondromatosis (multiple)
2. Osteoma (single); osteomatosis (multiple)
3. Ganglioma; neuroganglioma
4. Fibroma
5. Xanthoma, solid and cystic forms
6. Chloroma
7. Lipoma and lipophagic granuloma
8. Myxoma
9. Hemangioma and lymphangioma
10. Meniscal cysts
11. Traumatic hypertrophy and sclerosis of Hoffa's fat pad

B. Malignant

1. Synovial epithelioma, mesothelioma, endothelioma and perithelioma
2. Sarcoma: fibrosarcoma, spindle-cell sarcoma, round-cell sarcoma, giant-cell sarcoma
3. Myxochondrosarcoma and polymorphous sarcoma

Tumors of the joint capsule range with the tumors of the tendon sheaths and of the serous membranes and because of their topographical location and histologic structure present a similar and fairly characteristic pathological pattern and physiological behavior. The synovial membrane and the paracapsular tissues (16) are the site of origin. The largest group consists of cartilaginous tumors due either to faulty mesenchymal differentiation or to traumatic detachment of chondroblast elements with subsequent synovial impla tation (3). Chondroma and chondromat sis may follow osteochondritis dissecan chronic hypertrophic osteoarthritis, neur genic arthropathies, hemophilia, asep necrosis, ochronotic alkaptonuria, po infectious joint destruction, meniscal tea and other cartilaginous damage (4, 13).

While the roentgen appearance of jo chondromatosis is well known, reports osteoma of the knee joint have been sca Kienböck in 1924 (8) reported an intrac sular osteoma of the knee with a corr preoperative diagnosis. He was able collect from the literature similar lesi reported during the roentgen era by Ma chand in 1917, M. B. Schmidt in 191 Trapp in 1896, Rumpel in 1908, and Baetjer and Waters (1) in 1921. Th roentgen diagnoses in these cases wer variously, exostosis of tibia, fibula, a patella, osteogenic tumor, and access patella. By carefully redrawing the rad graphic images, however, and by study the operative reports, Kienböck was a to identify the roentgenologic and surg findings with those in his own case. S eral more examples were seen by Ki böck up to 1934, and in his standard w on "The Roentgen Diagnosis of Bone Joint Diseases" he concludes that oste occurs rarely in other joints, such as elbow, hip, shoulder, and ankle, that size of the tumor is hardly in propor to the low degree of functional imp ment, that incarceration does not occ and that the blood vessels and surround skeletal parts are never invaded. Oste of the knee joint is a new growth of sy vial origin and it therefore belongs to group of mesenchymal hyperplasias dysplasias.

[1] From the Department of Radiology of the New York Hospital, New York, N. Y. Accepted for publi n November 1944.

Fig. 1. Case I. Patella-shaped shadow of osteoma :neath the patella. Adjoining bone surfaces are :ooth.

Since the establishment of the clinical, entgenologic, and pathologic character- .ics by Kienböck, osteoma of the knee int has been reported by Böhm (2), ammer (6), Jerusalem (7), Laurence (10), azemon and Bizard (12), Robillard (13), :hnaberth (14), Simon (15), and Weiss ıd Löwenstein (17). Only two cases .ve been found in the American literature ,aetjer and Waters; Robillard). Four ɔre cases of this rare joint condition have ,en seen by the author.

CASE REPORTS

:ASE I: This observation dates back over fifteen :rs and a detailed history is not available. The ,ient was a middle-aged housewife with pain and ,ne limitation of motion in the left knee. She re- ,ed many years of floor sweeping while a girl. A d mass could be felt somewhat lateral to and be- : the left patella.

Roentgen examination revealed a well delineated :y tumor with small areas of increased radiolu- cy. The outlines of the tibial surface were irregular and hazy and there was slight subchondral demineralization (Fig. 1). The specimen removed by operation was a solid bony tumor with some fibrous, cartilaginous, and fatty tissues on the surface. Hoffa's fat pad was completely atrophied.

CASE II: A white housewife, aged 51, was admitted for pain and stiffness of the legs and knees, especially of the left knee. The pain was burning in type and worse at rest than after a period of limbering up. The knee became progressively more stiff and could not be flexed beyond a right angle. The joint was swollen, and palpation yielded a solid sense of fullness but no evidence of fluid.

Roentgenograms revealed a large, well delineated shadow of bony density just beneath the patella, overlying the opposing surfaces of the lateral femoral and tibial condyles. The shadow was well separated from the adjoining bones, and the joint surfaces were negative for evidence of invasion, erosion, or decalcification (Fig. 2). At operation a tumor, 5 × 4 × 2.5 cm. was easily removed from the retrofascial cavity. The fat pad was completely gone and the tumor had displaced the patellar ligament in a lateral direction. The specimen (Fig. 3) consisted of a hard tumor with a uniformly smooth and unbroken surface, containing cartilage. Microscopic examination showed bone with fat marrow and many small blood vessels. Along the edge were many osteoblasts which were actively laying down bone. The patient made an uneventful recovery and regained almost complete free mobility of the joint (Fig. 4).

CASE III: An Italian born male barber, aged 47, had noticed a hard lump on the left knee for ten months, with pain after sitting in one position. There was no history of a single injury, but the patient admitted having hit the left knee many times on the barber chair since boyhood. The knee became swollen on the anterior aspect but it was not tender to palpation except when in flexion or extension. There was an ovoid hard mass just below and medially to the left patella, not tender and freely movable apart from the patella itself. There was no limitation of motion of the knee joint.

Roentgenograms revealed a well delineated ovoid bony shadow beneath the patella, by which it was in parts overlapped. There was normal bony trabeculation, with some rarefied areas, in this shadow. Slight osteoarthritic changes of the joint surfaces were present (Fig. 5). At operation a bony tumor 4 × 4 × 2 cm., was easily removed, leaving the joint capsule intact. The tumor was in no way directly connected with the patella, and the fat pad was well preserved.

The tumor was covered with fibrous tissue and the exterior was not unlike cartilage. Microscopic sections revealed a trabeculated pattern of highly vascularized bone with hyaline cartilage and with thick fibrous tissue on the surface. After an uneventful postoperative course, the patient recovered almost normal mobility of the knee.

The latter areas contain roentgen-negative tissues, such as fibrous, synovial, fatty, and cartilaginous elements. There is a more or less continuous dense outer shell, and the shape of the shadow may be that of an hourglass, an Indian club, an egg, or of the patella. The shadow usually occupies a large part of the anterior compartment of the knee joint and more often lies laterally than medially. The position may vary, however, and similar tumors have been observed anywhere within the upper and lower, the anterior and posterior portions of the joint capsule. The tumor can always be separated from the adjoining skeletal parts. Herein lies the distinction between joint osteoma and osteogenic tumors, such as exostosis, osteochondroma, and giant-cell tumor of the bone.

Fig. 6. Case IV. Transversely placed patella-shaped bone shadow at level of the joint space. The patella is dislocated upward.

The differential diagnosis between osteoma and sesamoids, accessory or bipartite patella, inflammatory granuloma, loosened exostosis, calcified hematoma, and malignant tumor offers little difficulty. Joint chondromatosis frequently shows more or less extensive, though irregular, islands of calcification and rarely true bony elements. Chondromatous lesions are *more frequently* multiple than single, and they may occur anywhere within or without the joint capsule. Post-traumatic necrosis and sclerosis of Hoffa's fat pad never attain the si[ze] and density of an osteoma. The fat pad i[s] either displaced or completely atrophi[c] from long-standing pressure rather than th[e] original site of a metaplastic bone forma- tion (13, 14). The calcium content of th[e] knee bones is usually normal, but increase[d] functional impairment may lead to slig[ht] subchondral demineralization.

CONCLUSIONS

Benign osteoma of the knee joint is ra[re]. Roentgenograms show characteris[tic] findings, differing from those in oth[er] arthrogenic tumors such as chondromato[sis] (joint mice). The absence of any b[ony] connection between the tumor and the a[d-] joining bony structures can readily be de[m-] onstrated. The history usually ranges o[ver] many years and often dates back to tr[au-] matism during the age of bone grow[th] with repeated mechanical damage to th[e] knee in the interval. The size of the tu[mor] as shown on roentgenograms and at ope[ra-] tion is barely in proportion to the h[igh-] grade functional impairment and clin[ical] complaints. Symptoms and signs seem [to] become more marked as the patient ent[ers] middle age.

The etiology of joint osteoma is still o[b-] scure. Our observations and those

hers (3, 12) seem to support the opinion Kienböck that infection plays no part id that a single injury can hardly be the use of the condition. Since repeated aumatism of occupational or athletic aracter can be traced in the majority of e patients, over many years, it can be as- med that mechanical influences induce a roliferation of a normally dormant, bio- gically polyvalent, and potentially bone- rming synovial tissue. Whether the pri- ary damage of the synovial cells consists a constitutional embryonal aberration r a traumatic detachment, with subse- uent implantation before the termina- on of bone growth, cannot be decided. isidious proliferation of dormant embry- nal cell rests with metaplastic changes is ell known in tumor pathology. A similar rigin of the joint osteoma from synovial nplantations under the impact of repeated echanical damage over a long period of me conforms well with the present con- eption of tumor formation.

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Filing and Cross-Indexing of Radiation Therapy Records[1]

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In a previous publication (1) certain principles governing the filing and especially the cross-indexing of roentgen-ray diagnostic records were presented. These may be summarized as follows:

1. The clinical experience embodied in accumulated roentgen-ray records is of little value for either teaching or investigative purposes unless it can be approached in a systematic fashion, namely, through a sound method of cross-indexing.

2. A cross-indexing system is inextricably related to the method of handling the roentgen-ray records; indexing is valueless unless the records are filed so as to be readily available when located within the scheme of codification.

3. A cross-indexing system must be simple both in respect to the clerical effort involved and in the fineness of its subdivisions. Inordinately detailed categorization is impracticable and may result in the expenditure of excessive labor in maintaining the system. The primary objective of the cross-index is to simplify the tedious search through large masses of records for material pertinent to some particular purpose.

4. Division of all diagnoses to be classified into a number of broad diagnostic fields simplifies the coding scheme and minimizes labor. The field system automatically breaks down the mass of diagnoses into a number of groups, and the process of recovery of material is limited to a search within one of these rather than the total bulk of the records.

To translate these principles into practice, a coding scheme was presented which, with a minimum of clerical work, provided multiple diagnostic categories, within ten main divisions, of the abnormal findings possible in the field of diagnostic roentgenology. A separate code of nor[mal] findings, likewise divided into ten ma[in] fields, provided immediate segregation [of] normal from abnormal observations. T[he] simplicity of the hand-scoring method a[nd] the ease of locating the desired diagno[stic] categories in the various fields (employi[ng] in loose-leaf form, ruled normal and a[b]normal pages for each field) have ma[de] this method intensely practical and it [...]

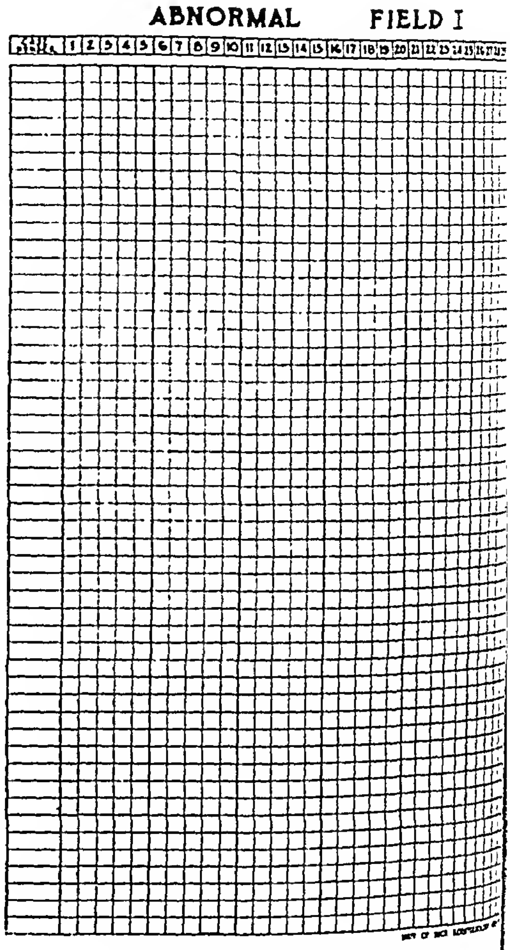

Fig. 1. Reproduction of the standard notebook [...] for indexing radiation therapy cases. This page is [the] same as that used for abnormal findings in the diag[nos]tic cross-index. The form page has been numbered [...] for the Female Genital Tract.

[1] From the Department of Roentgenology, University Hospital, University of Michigan. Accepted for publication in February 1945.

ined considerable popularity among ra-ologists.

For the past four years in the Section on adiation Therapy of the Department of oentgenology at the University of Michi-in, a cross-indexing system and coding an based on principles identical with ie diagnostic method and similar in ex-rnal form have been employed with sat-actory results. With minor clerical fort the case records of all patients ir-diated are catalogued into pertinent tegories, distributed among a number of oss divisions (fields) of the entities en-untered in radiation therapy practice. ie mechanism of the system is such that, mediately upon cataloguing, the records e available for recall from the files for e in clinical investigation, teaching, or r other purposes. The indexed data corded on form sheets (Fig. 1) by hand oring lend themselves readily to tabula-on of certain crude statistics on the umber of cases treated. Since the case lume is usually considerably smaller in diation therapy practice than in diag-stic roentgenology, in certain respects eater particularization is feasible and a eans of providing this has been incor-rated without altering the basic struc-re of the plan.

In Table I the major divisions of the de employed at the University of Michi-n are listed. Perusal of this table shows at no attempt has been made to create orderly classification of disease either a histopathological or an anatomical sis. The divisions have been made gely but not exclusively on anatomical ounds; Fields X and XI and a portion IX are the exceptions. The particular eakdown shown in this table is totally bitrary and was made for reasons of con-nience as dictated by local interests and st experiences. The number of fields, ven, may appear unnecessarily high, t this was purposeful, in order to keep wn the number of categories within each, mitting the introduction of the notation chanism which is described later. These ds (and their subdivisions in Table II) are not presented as a scheme of universal applicability but rather to serve as an example of the application of the principles of the method. Each radiologist will undoubtedly find it to his advantage to establish a set of fields which more specifically meets the demands of his own practice.

TABLE I: MAJOR DIVISIONS OF THE RADIATION THERAPY CODE

FIELD I	Female Genital Tract
FIELD II	Male Genital Tract; Urinary Tract
FIELD III	Breast
FIELD IV	Lip and Mouth
FIELD V	Sinuses, Pharynx, Larynx, Thyroid
FIELD VI	Skin
FIELD VII	Gastro-intestinal Tract
FIELD VIII	Eye, Brain, Spinal Cord; Thorax
FIELD IX	Bone; Metastatic Neoplasm (Primary Unknown)
FIELD X	Lymphoblastoma; General
FIELD XI	Inflammations; Miscellany

In Table II the complete indexing code for radiation therapy cases is presented, listing the individual diagnoses used within each field along with their identifying sub-numbers. In order to distinguish clearly between field number and sub-number, the former is always written as a Roman numeral followed by an Arabic numeral as the sub-number; for example, "Carcinoma Cervix Uteri" is indicated by I-1. Study of this table shows that the diagnoses within the fields likewise do not follow any consistent histopathological or anatomical classification. The contents of the first ten fields are devoted predominantly to the various neoplasias, while Field XI is entirely constituted of non-neoplastic disorders, providing categories for a variety of inflammatory and miscellaneous conditions. This segregation is not absolute, since provision is made in the first ten fields for certain non-neoplastic entities. Examples of the latter are (1) "Disease Male Genital Tract XAL," Field II, category 6, which we have used for Peyronie's disease, sterilization for spermatocele, etc.; (2) Field V, category 13, "Disease Thyroid XAL," used for hyperthyroidism, thyroiditis, etc.

The diagnoses which appear within each field have been selected for a variety of reasons. Some have been chosen because of their high frequency of occurrence.

TABLE II: INDEXING CODE FOR RADIATION THERAPY CASES

Field I: Female Genital Tract

1. Carcinoma Cervix Uteri
2. Carcinoma Corpus Uteri
3. Neoplasm Uterus XAL
4. Carcinoma Vulva
5. Carcinoma Vagina
6. Neoplasm Ovary
7. Neoplasm Female Pelvis, Unspecified
8. Neoplasm Female Genital Tract XAL
9. Endometriosis (any site)
10. Castration, Uterine or Ovarian Disorder
11. Castration XAL
12. Disease Female Genital Tract XAL

Field II: Male Genital Tract

1. Carcinoma Penis
2. Carcinoma Scrotum
3. Carcinoma Prostate
4. Neoplasm Testicle
5. Neoplasm Male Genital Tract XAL
6. Disease Male Genital Tract XAL

Urinary Tract

10. Neoplasm Bladder
11. Neoplasm Kidney XAL
12. Wilms' Tumor
13. Neoplasm Urethra, Ureter
14. Neoplasm Urinary Tract XAL
15. Disease Urinary Tract XAL

Field III: Breast

1. Carcinoma Breast (no previous surgery), Preoperative Irradiation
2. Carcinoma Breast (no previous surgery), Inoperable (specify why)
3. Carcinoma Breast, Postoperative
   Specify type of operation: radical, modified radical, simple
4. Carcinoma Breast, Previous Treatment
   Recurrence or Metastases (specify involvement)
5. Neoplasm Breast XAL
6. Mastopathia Cystica
7. Disease Breast XAL

Field IV: Lip and Mouth

1. Carcinoma Lip, "massive concentrated" } Primary only treated
2. Carcinoma Lip, other irradiation } Primary only treated
3. Carcinoma Lip, irradiation of primary and metastases
4. Carcinoma Lip, XAL
5. Carcinoma Buccal Mucosa
6. Carcinoma Alveolar Mucosa
7. Carcinoma Palate
8. Carcinoma Floor of Mouth
9. Carcinoma Base of Tongue
10. Carcinoma Tongue XAL
11. Carcinoma Mouth, origin indeterminate
12. Neoplasm Lip, Mouth, Tongue XAL

Field V: Sinuses, Pharynx, Larynx, and Thyroid

1. Carcinoma Nose, except skin
2. Carcinoma Paranasal Sinuses
3. Neoplasm Nose and Sinuses XAL
4. Carcinoma Nasopharynx
5. Neoplasm Nasopharynx XAL
6. Neoplasm Auditory Canal, Middle Ear, Mastoid
7. Neoplasm Tonsil, Tonsillar Region
8. Carcinoma Pharynx, Hypopharynx
9. Carcinoma Larynx
10. Neoplasm Pharynx, Hypopharynx, Larynx XAL
11. Neoplasm Salivary Glands
12. Neoplasm Thyroid
13. Disease Thyroid XAL

Field VI: Skin

(Specify Histological Type)

1. Carcinoma Skin: Upper Extremity
2. Carcinoma Skin: Lower Extremity
3. Carcinoma Skin: Trunk
4. Carcinoma Skin: Neck
5. Carcinoma Skin: Nose
6. Carcinoma Skin: Ear
7. Carcinoma Skin: Scalp
8. Carcinoma Skin: Eyelids, Canthi
9. Carcinoma Skin: Face XAL
10. Hemangioma Skin, Subcutaneous Tissues
11. Neoplasm Skin XAL

Field VII: Gastro-Intestinal Tract

1. Neoplasm Esophagus
2. Neoplasm Stomach
3. Neoplasm Small Bowel
4. Neoplasm Colon, Rectum
5. Neoplasm Anus
6. Neoplasm Liver
7. Neoplasm Pancreas
8. Neoplasm Gastro-intestinal Tract XAL
9. Neoplasm Abdomen XAL
10. Neoplasm Retroperitoneum XAL (Adrenal)

Field VIII: Eye, Brain, Spinal Cord; Thorax

1. Carcinoma Conjunctiva
2. Carcinoma Orbit
3. Neoplasm Eye, Eyelid XAL
4. Disease Eye, Eyelid XAL
5. Pituitary Adenoma
6. Medulloblastoma
7. Neoplasm Brain XAL
8. Disease Brain XAL
9. Neoplasm Spinal Cord XAL
10. Disease Spinal Cord XAL

11. Carcinoma Bronchus
12. Neoplasm Lung XAL
13. Neoplasm Mediastinum XAL
14. Neoplasm Intrathoracic XAL
15. Neoplasm Thoracic Wall

Field IX: Bone

1. Giant-cell Tumor
2. Osteogenic Sarcoma
3. Chondrosarcoma
4. Ewing's Tumor
5. Sarcoma Bone XAL
6. Myeloma, Multiple Myeloma
7. Neoplasm Bone XAL
8. Xanthomatosis
9. Disease Bone XAL

Metastatic Neoplasm, Primary Unknown

10. Metastatic Neoplasm: Neck, Supraclavicular
11. Metastatic Neoplasm: Skull, Brain
12. Metastatic Neoplasm: Skeletal XAL
13. Metastatic Neoplasm: Lungs, Mediastinum, P[illegible]
14. Metastatic Neoplasm: Abdomen
15. Metastatic Neoplasm: Retroperitoneal
16. Metastatic Neoplasm: Soft Tissues XAL

Field X: Lymphoblastoma; General

Hodgkin's Disease
Lymphosarcoma
Lymphoblastoma XAL
"Test of Irradiation" for Lymphoblastoma
Lymphatic Leukemia
Myelogenous Leukemia
Monocytic Leukemia
Leukemia XAL
Polycythemia
Disease Blood XAL

Hemangioma XAL*
Lymphangioma*
Melanoblastoma, Amelanotic Melanoblastoma*
Sarcoma XAL (organ site category preferable if available)
Neoplasm XAL

Also use organ site category if available.

Field XI: Inflammations; Miscellany

1. Furuncle, Abscess, Carbuncle
2. Cellulitis, Phlegmon
3. Parotitis
4. Adenitis, Non-tuberculous
5. Mycotic and Unusual Infections: Actinomycosis, Blastomycosis, Rhinoscleroma, etc.
6. Adenitis, Tuberculous
7. Otitis Media, Peritubal Lymphoid Hypertrophy, Other Otological Infections
8. Other Inflammations or Infections
10. Thymic Enlargement
11. Keloid
12. Warts, Corns
13. Peptic Ulcer, Gastritis, Hyperacidity
14. Depression Salivary Secretion
15. Herpes Zoster, Neuralgias, etc.
16. Arthritis, Specify Type
17. Miscellany XAL

hers, which may occur relatively in-quently, appear because of a special erest on our part in these diseases. other instances a relatively rare disease y be given a category to itself to avoid rching through a large number of rec-s of a frequently occurring closely re-ed disorder. Those familiar with the nic of setting up an inclusive coding hanism will recognize the use of cer-categories for the sole purpose of pro-ing pigeonholes which will sweep up ations not provided for elsewhere but ch do not merit individual considera-. As stated previously, this indexing e is not presented with the thought t it will prove to be equally satisfac- for all radiation therapy practices, rather as an example of the application his method. Radiologists who include radiation treatment of dermatitides dermatoses in their work will find no vision for these diseases since at our tution this work is carried on in an-r department. These diseases can be ed readily by means of an additional or by incorporating the necessary gories into Field VI, which deals with

order to insure efficient operation of coding scheme, several simple princi-must be faithfully observed. Of para-nt importance is the fact that the plan for handling of the neoplastic enti-on the basis of the primary site of the lesion. This principle holds regardless of whether the primary lesion or its metastases or both have been treated; in any of these events, the case is indexed in the category bearing the label of the primary tumor. For those cases presenting obvious metastases derived from an unknown primary tumor, provision for codification is found in Field IX, categories 10 to 16, inclusive; these diagnoses are not used to specify the sites of metastasis from a known primary lesion.

Throughout the code, the terms "carcinoma" and "neoplasm" are used in their precise senses and are not interchangeable. A malignant neoplasm which is not a carcinoma must not be placed in a category labeled "carcinoma" of the involved part but in a suitable category bearing the specific histological diagnosis or in one labeled "neoplasm." Neoplasm, of course, includes all types of neoplasia. For example, a sarcoma of the body of the uterus is catalogued as Field I-3 ("Neoplasm Uterus XAL"); it is not entered in I-2 ("Carcinoma Corpus Uteri"). Any neoplasm of the testicle: sarcomatous, carcinomatous, mixed, benign or malignant, is coded as II-4 ("Neoplasm Testicle"). The Wilms' tumor has its own category, II-12, while renal hypernephromas and carcinomas are cared for with II-11 ("Neoplasm Kidney XAL").

The designation "XAL" as it appears in Table II may be translated "except as

listed elsewhere in the code." "Lymphoblastoma XAL" (X-3) refers to any type of lymphoblastoma other than those listed, namely, "Hodgkin's disease" (X-1), "lymphosarcoma" (X-2), and the leukemias (X-5, 6, 7, 8). "Neoplasm Mediastinum XAL" (VIII-13) provides for mediastinal tumors other than lymphoblastomatous masses, since the latter are codified in Field X. A final example of the use of the "XAL" designation is X-15 entitled "Neoplasm XAL"; this is a pigeonhole purposefully created to house an occasional situation not provided for elsewhere in the code and in our experience has been used rarely.

Although the standard form[2] employed (Fig. 1) provides space for as many as thirty categories within each field, the radiation therapy code within each of its fields never calls for this maximal number. Field XI, containing seventeen categories, requires seventeen of the thirty columns; the other fields use less. This leaves space on the right-hand side of each page which is employed to advantage by entering brief notes. These notations can serve to provide greater specificity than is inherent in the category title or may be used to call attention to striking or interesting features of any case. In Fields III, VI, and XI, the code calls for specification by means of notes of such items as the reason for inoperability in the case of mammary tumors, the type of operation, the sites of recurrence and metastasis, and the histological type of cutaneous carcinomas. The notation feature may be used to specify the precise histologic character of a lesion whenever the category bears the broad label of neoplasm and also to specify location when this does not appear in the category title. Examples of the former are: I-6, adenocarcinoma (the title of this category is "Neoplasm Ovary," the notation "adenocarcinoma" gives the precise histological type); V-7, carcinoma (the la... of this category is "Neoplasm Tonsil"). Examples of specification of anatomic location are: VI-10, cheek (this category is labeled "Hemangioma Skin, Subcutaneous Tissues"; the notation "cheek" sta... the precise site); IX-4, femur (thus loc...ing the Ewing's tumor in the femur); XI-... face (indicating the presence of a furu... on the face).

Obviously the notation scheme ... be used to indicate the type of treat... or the chronological relation of irradia... to operation. Spectacular or unexpect... poor responses to irradiation may be ...beled; unusual age incidence and ... other items of interest may be incorpora... to facilitate subsequent location of ... material. The notation feature is ela... and may be employed as broadly or as ...rowly as one's interests dictate.

In practice it has been our custom ... codify each case at the time of complet... rather than at the beginning of a treatm... program. On the patient's radiation the...apy record, near the discharge note, ... coded statement appears, Roman ...merals being employed for field designat... and Arabic numbers for the diag... within the field. The entering of this ma...terial on the standard forms is usually d... daily. A loose-leaf notebook conta... eleven standard forms, one for each fi... properly labeled as to field number, ... maintained. The case number is ent... in the left-hand column; in the pr... column an X is hand-scored and o... right side of the page the desired nota... are inscribed. With the 1,300 to 1,50... tients treated each year in our depart... it has been found that five to ten mi... daily are required to code and record ... cases; a negligible investment of t... which yields rich rewards in ability ... recover valuable clinical material.

To illustrate the technic and appear... of the completed coding and reco... process in the various field forms, Fig... and Table III are presented. In Fig... samples of indexed cases from va... fields are shown: the case number ide...

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[2] This form is the same as that used for abnormal findings in the indexing scheme for diagnostic roentgenology and may be obtained from Edwards Bros., Inc., Ann Arbor, Mich. It was more convenient to use this existing form than to create a special form for the radiation therapy code.

ing the patient appears in the left-hand ılumn, the hand-scored X is present in ıe column corresponding to the number the diagnosis as found in the indexing ›de (Table II), and on the right side of ıe sheet are various notations. Table III, ›aling with the cases shown in Figure 2, ay serve to translate and amplify the aterial recorded in this figure. The diag›sis is compared with the category label the indexing code (Table II) and the ›ded statement for each diagnosis is ven along with the notations used in ese cases.

One feature regarding case records in diation therapy must be noted. With ı indexing system such as is presented re, it is eminently desirable that each se be characterized by a single case num›r which is reassigned to the patient at ıatever future date he may return. The ırticular form of the radiation therapy ›cord may vary widely. The record at e University Hospital consists of 3 ele›nts: (1) the original refer if the case is erred from another department for raıtion treatment; (2) the treatment ›ets containing the detailed data of ysical factors, dosage, and location of ›s for roentgen and radium therapy; the sheets devoted to history, physical dings, radiation prescriptions, clinical ›gress notes, and discharge notes. The ee elements are kept in a single envee bearing the patient's name and registion number and are maintained on file the radiation therapy department. All material in the record is created in du›ate as the record develops, and the ies appear in the general hospital recof the case. Thus the complete radiaı therapy story of any case, including ailed physical factors of treatment, is ilable in the patient's hospital record vell as in the record housed in the Detment of Roentgenology. We believe this must be done in fairness to the ent, the hospital, and all the physicians olved.

s in the system previously described diagnostic roentgenology, total inci-dence figures are readily obtainable for any desired finite period by a simple count of the scores within any pertinent column. It has been found convenient to separate the months by entering the month date to the left of the case number column

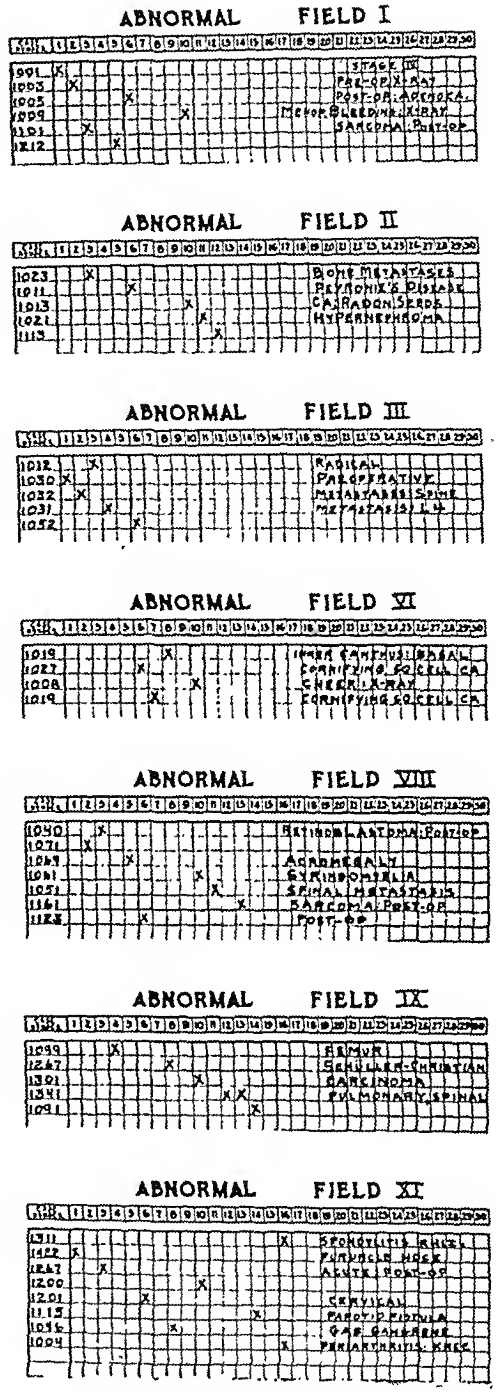

Fig. 2. Samples of indexing forms for radiation therapy cases for various fields. Coding examples in Table III have been entered here to demonstrate the completed process of cross-indexing.

TABLE III: SAMPLE OF CODING AND RECORDING

Case No.	Diagnosis	Category Label	Code	Notation
		Field I		
1001	Carcinoma cervix uteri	Same	I-1	Stage IV
1003	Carcinoma corpus uteri	Same	I-2	Preoperative roentg[illegible] radiation
1005	Adenocarcinoma of ovary	Neoplasm Ovary	I-6	Adenocarcinoma, p[illegible]erative
1009	Menopausal bleeding	Castration (Uterine or Ovarian Disorder)	I-10	Menopausal bleed[illegible] roentgen irradi[illegible]
1101	Sarcoma of uterus	Neoplasm Uterus XAL	I-3	Sarcoma, postop[illegible]
1212	Carcinoma of vagina	Same	I-5	
		Field II		
1023	Carcinoma of prostate	Same	II-3	Bone metastases
1011	Peyronie's disease	Disease Male Genital Tract XAL	II-6	Peyronie's disease
1013	Carcinoma of bladder	Neoplasm Bladder	II-10	Carcinoma; rado[illegible]
1021	Hypernephroma of kidney	Neoplasm Kidney XAL	II-11	Hypernephroma
1113	Wilms' tumor	Same	II-12	
		Field III		
1012	Carcinoma of breast, postoperative	See Table II, Field III-3	III-3	Radical operation
1030	Carcinoma of breast, preoperative irradiation	See Table II, Field III-1	III-1	Preoperative
1032	Carcinoma of breast, spinal metastases	See Table II, Field III-2	III-2	Metastases spine
1031	Carcinoma of breast, spinal metastasis (previous surgery)	See Table II, Field III-4	III-4	Metastasis L4
1052	Mastopathia cystica	Same	III-6	
		Field VI		
1019	Basal-cell carcinoma of inner canthus	Carcinoma Skin: Eyelids, Canthi	VI-8	Inner canthus, basal
1027	Cornifying squamous-cell carcinoma of skin of ear	Carcinoma Skin: Ear	VI-6	Cornifying squam[illegible] carcinoma
1008	Cavernous hemangioma, cheek	Hemangioma Skin, Subcutaneous Tissues	VI-10	Cheek; x-ray
1019	Cornifying squamous-cell carcinoma of scalp	Carcinoma Skin: Scalp	VI-7	Cornifying squam[illegible] carcinoma
		Field VIII		
1040	Retinoblastoma right eye, postoperative	Neoplasm Eye, Eyelid XAL	VIII-3	Retinoblastoma, p[illegible]erative
1071	Carcinoma of orbit	Same	VIII-2	
1069	Acromegaly	Pituitary Adenoma	VIII-5	Acromegaly
1061	Syringomyelia	Disease Spinal Cord XAL	VIII-10	Syringomyelia
1051	Carcinoma of bronchus with spinal metastasis	Carcinoma Bronchus	VIII-11	Spinal metastasis
1161	Sarcoma of mediastinum, postoperative	Neoplasm Mediastinum	VIII-13	Sarcoma, postop[illegible]
1123	Medulloblastoma, postoperative	Medulloblastoma	VIII-6	Postoperative
		Field IX		
1099	Ewing's tumor of femur	Ewing's Tumor	IX-4	Femur
1267	Schüller-Christian's disease	Xanthomatosis	IX-8	Schüller-Christia[illegible]
1301	Metastatic carcinoma in neck, primary unknown	Metastatic Neoplasm: Neck, Supraclavicular	IX-10	Carcinoma
1341	Pulmonary and spinal metastases, primary unknown	Metastatic Neoplasm: Skeletal XAL; Metastatic Neoplasm: Lungs, Mediastinum, Hila	IX-12, 13	Pulmonary, spinal
1091	Abdominal metastases, primary unknown	Metastatic Neoplasm: Abdomen	IX-14	

Field XI

311	Spondylitis rhizomélique	Arthritis	XI-16	Spondylitis rhizomélique
422	Furuncle, nose	Furuncle, Abscess, Carbuncle	XI-1	Furuncle, nose
267	Acute postoperative parotitis	Parotitis	XI-3	Acute, postoperative
200	Thymic enlargement	Same	XI-10	
201	Tuberculous adenitis, cervical	Adenitis, Tuberculous	XI-6	Cervical
115	Parotid fistula	Depression Salivary Secretion	XI-14	Parotid fistula
)46	Gas gangrene	Other Inflammations or Infections	XI-8	Gas gangrene
)04	Periarthritis of knee	Arthritis	XI-16	Periarthritis, knee

the beginning of each new month. For tistical purposes it has been desirable ndicate repeated episodes of irradiation hin the calendar year by means of an erisk immediately to the left of the case nber; to obtain counts of the number of ients, those numbers marked with an erisk are omitted. Likewise, one may icate by means of another symbol cases ch were treated in previous years. It ossible at the end of a calendar year to ain a statistical survey of the number of ients treated for the various diseases alogued, by the expenditure of only a hours in tabulating column counts. s procedure is carried out yearly in department; usually by the end of the week in January the survey of the en- preceding year is prepared and may be pared with the experience of the earlier rs.

he recovery of case material from the hand-scored sheets is a matter of utter simplicity. The radiologist turns to the proper field sheet in the loose-leaf book, locates the column bearing the desired diagnostic number, and scans it for the hand-scored X's. The corresponding case number is found in the left-hand column and the case record may then be located in the files on the basis of this number. This may be achieved by maintaining the records in the file in serial order of case number. If it is deemed advisable to file the records in alphabetical order by name, a number-name card index will provide for transition from case number to patient's name.

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REFERENCE

1. HODGES, FRED J., AND LAMPE, ISADORE: Filing and Cross-Indexing Roentgen Ray Records. Am. J. Roentgenol. 41: 1007–1018, June 1939.

Cross-Indexing of Roentgen Diagnostic Records[1]

A Revision of the Hodges and Lampe Code

CAPT. BENJAMIN R. VAN ZWALUWENBURG, M.C., A.U.S.

WHEN THE roentgenologist has exposed and developed his second roentgenogram the task of keeping track of his accumulated experience begins. At that stage the problem is a simple one. The location of the two films with their findings can easily be kept in mind and either can be located for comparison with future examinations. The sum total of that individual's recorded roentgenological experience is immediately available.

As examination follows examination, the situation becomes vastly different. The present-day volume of roentgenological work is so large that each day's cases are soon submerged by the continuing flow. The interesting cases are lost sight of, and the surprisingly large experience represented by thousands of examinations is not available for orderly review. To prevent this loss, a systematic means of access to the accumulated material becomes a necessity in every roentgenological office and department.

Various systems of cross-indexing have been applied to this problem. The most common is the card-index system, which has many variations, all based on the same principle. A card is prepared for each diagnosis, and the diagnosis is indicated at the top by title or by a code number. If the method is to be practicable, the less common diagnoses must be grouped several to a card in order to decrease the number of cards and thus simplify the clerical work. Every day the names or file numbers of the patients are written in on the proper cards.

The card-index method is direct. Its chief disadvantage is that a separate card must be maintained for each diagnostic category. If all the possible diagnoses are grouped into 300 categories, for insta- 300 cards must be used, and the cle- work of entering cases on the cards is c- respondingly complex.

In 1939 Hodges and Lampe (1) i- duced the loose-leaf "score sheet" pri- as a means of simplification. The- placed the library card by a score - 8 1/2 by 11 inches, ruled into 30 ver- columns and 50 horizontal columns.[2] - horizontal column is thus divided in- squares. Each vertical column repre- a diagnosis or diagnostic category a- identified by a number. Each horiz- column represents one examination a- identified by writing the patient's number in the left-hand space. The d- nosis made on that case is then indic- by a check mark or other symbol plac- the square at the intersection of the h- zontal column with the proper ver- column. The score sheet, in compa- to the index card, may be said to be tw- mensional, since it will accommodate - diagnoses as well as many patients. Th- diagnostic categories are included on - sheet, making it possible to use onl- sheets for 300 diagnostic categories.

To use these score sheets Hodges - Lampe divide all roentgenological - noses into 10 major anatomic gr- which they term "fields," and further - divide each field into 30 categories. - more common diagnoses are repre- by separate categories; the less co- diagnoses are grouped several to a c- gory. The entire gamut of roentgen- cal diagnoses is thus divided into - categories, grouped in 10 anatomic f- and tabulated on 10 sheets.

A second parallel system of eight - tomic fields and eight more score she-

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[1] From the Radiological Service, O'Reilly General Hospital, Springfield, Mo. Accepted for publication - cember 1944.

[2] Available in printed form from Edwards Bros., Ann Arbor, Mich.

provided, with which to index negative findings, classified according to the type of examination.

At the close of the dictation of each report, the radiologist refers to the code and indicates a code number which is typed on the report and serves as a guide to the stenographer who later enters the case on the appropriate score sheet. This code number consists of a Roman numeral to indicate the field and an Arabic numeral to indicate the diagnostic category within the field. The Roman numerals therefore run from I through X and the Arabic numerals from 1 through 30. An asterisk replaces the check mark in the appropriate space to emphasize a case of unusual interest, while a question mark qualifies an uncertain diagnosis. Alphabetical letters are provided in some fields to further specify location. When needed, they are dictated following the code number. The proper column on the score sheet is then marked by writing in the letter instead of by the usual check mark.

Since its introduction, the score-sheet cross-indexing system has been adopted by many roentgenological offices and departments. It has proved capable of handling a large volume of material without an undue clerical burden. But, as Hodges and Lampe pointed out, the cross-index must be tailored to fit the type of work being done and the particular use to which it is to be put. Thus it is to be expected that those using the cross-index will arrive at individual variations, both in usage and in construction of the code. It is to be emphasized that each radiologist, after experience with the code system, can profitably make his own personal variations. Periodic revision also is necessary to bring the code up to date and to adapt it more efficiently to the work being done. Such a revision is presented here, together with a discussion of how the code may be used for various purposes.

SUGGESTED CHANGES IN CODE

The separation of the diagnoses into anatomic fields provides, in effect, 10 codes of 30 numbers each. Many diagnoses will occur in more than one of these fields. If the same code number is assigned in the various fields for those diagnoses which occur in more than one field, it will speed up the coding process by making it easier to remember the numbers.

Although this concept is followed to a certain extent in the Hodges and Lampe code, there are numerous violations. For example, they code a recent fracture as 12 or 18 in Field I, 10 in Field III, and 2 in Fields II, IV, and V. In the code published herewith, fracture is coded as number 3 in no matter what field it occurs—bones of face, skull, spine, or extremities. The single relationship "fracture is 3" is more easily remembered than "fracture is 12, 18, 10, or 2." In the revised code, identical access numbers have been provided for similar diagnoses in all fields throughout the code.

2. The second change in the code is the alteration of certain categories to keep up with recent progress in medical concepts. This reclassification was carried farthest in Field VII (Lungs and Pleura, non-tuberculous). The previous classification of non-tuberculous pulmonary infections included:

6. Pneumonia, lobar
7. Pneumonia, resolving or resolved
8. Pneumonia, unresolved
9. Pneumonia, except as above
14. Pneumonitis, suppurative
15. Pneumonitis, except as above
16. Abscess, cyst

The revised classification of this group is as follows:

3. Bronchopneumonia and primary atypical pneumonia
4. Lobar pneumonia
5. Abscess and suppurative pneumonitis
6. Pneumonia and pneumonitis, except as above (including fungus, sarcoid, tularemic and chronic fibroid pneumonia)

It is felt that there will be less variation in coding cases under this latter classification and that, therefore, the code will be of more value when it is eventually called upon to furnish cases for review or demonstration.

Other minor shifts in wording and grouping of the diagnostic categories have been made throughout the code. For the convenience of Army radiologists a code number for foreign body has been provided in every field except that of Thoracic Tuberculosis.

3. A mechanism has been added to separate the "repeat" diagnoses of follow-up examinations from the "new" diagnoses. This is of great practical importance to avoid reduplication in preparing lists of cases from the score sheets. In the Hodges and Lampe code, duodenal ulcer is indicated by IX-7. To prepare a list of cases of duodenal ulcer for review, one includes all the cases checked in column 7 on the Field IX sheets. One will find, however, that many of the examinations listed as IX-7 are follow-up examinations and, as a result, the same cases will recur several times in the list prepared. When finding groups of cases for review, these reduplications are readily recognized and are simply an annoyance. They are a decided handicap, however, in preparing statistics since, instead of merely counting the check marks in a given vertical column, it is necessary to make note of all the case numbers and to weed out carefully all the reduplications.

In the revised code presented herewith the follow-up examinations are differentiated from the new cases by the addition of the letter X to the code number of any diagnosis which has been previously coded on the same patient. These diagnoses are entered on the score sheet by a cross instead of a check mark. Thus the radiologist can determine how many duodenal ulcers he has diagnosed in the past year, for example, by simply counting the check marks in the proper column, omitting the crosses.

4. Question marks and asterisks are used in the original code to qualify questionable diagnoses and emphasize cases of special interest. This sometimes makes it necessary to crowd several symbols into one box. In the revised code this is avoided by assigning these functions to special vertical columns (numbers 28 and 30).

5. The Hodges and Lampe s
codes all examinations with normal
ings according to the type of examir
performed, but it does not provide
information for the abnormal cases.
quently the type of examination is
ous from the diagnosis, but in other
this is not so. For instance, a gallbl
calculus may be found on an otherwise
ative intravenous pyelogram. Such a
is coded as gallbladder calculus and w
be listed anywhere in the code as a p
graphic study. The only purpose of
ing negative examinations is statistical
it is of no value unless the compa
figures (classified in the same way, b
amination type) are available for the
normal cases.

In our revised code, therefore, a prov
is made (by letter in column 2) for
cating the type of examination in the
normal cases. Thus, an example of
full code indication is: VI-2 E, 13.
sheet VI an E will be entered in colu
to indicate a portable chest examin
(and column 13 will be checked to ind
cardiac enlargement). In this way a re
of the examination type can be made
all cases.

6. The second system of eight s
sheets used by Hodges and Lampe fo
cording the type of examination in neg
cases has been eliminated by using col
in each field for this purpose just as co
2 is used to code the examination ty
abnormal examinations. The numb
score sheets has thus been reduced f
18 to 10.

SUGGESTED VARIATIONS IN USE OF CODE

Most radiologists who use the s
sheet method for cross-indexing the
ports are coding all of their examin
For many of them, depending on the
to be made of the code, this is unnec
and time-wasting. The actual use ma
the cross-index has fallen into three
mon forms, depending on the interest
available study time of the individu
diologist:

.. The index may be used merely to te unusually interesting and instructive s for demonstration and teaching, or comparison with similar cases seen la- Used in this way, the cross-index the purpose of the "Special File" in h nearly every radiologist keeps his t cherished cases. In many war-time es this is the only function of the cross- x utilized; yet even this limited use ie code may be a source of great satis- ion to the radiologist.

this is the only use anticipated, it is ous that only cases of particular in- st need be coded and entered on the e sheets. Even in these cases the ex- iation type may be omitted and only diagnosis coded. This simplified usage the advantage of eliminating 98 per of the clerical work involved in full of the code.

The index may be used to locate s of cases for review and study. This ose requires a more complete utiliza- of the code than does use A. It will ecessary to code *all* of the abnormal inations. Negative examinations, ever, need not be coded, the repeat iinations may be omitted, and only diagnoses are needed (not the exami- on types). Columns 1 and 2 may, efore, be omitted. The clerical work be approximately 30 per cent of that lved in full usage of the code.

The fullest use of the cross-index is periodic statistical study. This ne- tates coding every case examined, us- he examination type columns, 1 and well as the diagnosis columns. Sim- ounting on the score sheets for any period will then determine the total ber of examinations or of patients ting re-examinations), the number of inations (or patients) of each type, the on of negative to positive results for type of examination, the number of any diagnosis has been made, the ve frequency of various diagnoses, Followed from year to year, the sheet will also indicate the trend in ne of the various types of work being done. In the case of a hospital department, this information may be particularly helpful in supporting requests for changes and additions in departmental equipment and personnel.

Each roentgenologist using the code must determine for what purposes he will employ it and should use only those portions which are necessary for his object.

TECHNIC OF USING THE CODE

At the close of dictation of each x-ray report, the code numbers of the case are dictated by the radiologist. The stenographer types these in a lower corner of the report and later transcribes all of the day's codes to the score sheets. The field numbers and diagnosis numbers are self-explanatory and remain the same regardless of how the code is being used.

Each field contains a listing of letters headed "Examination Type or Localization." In some fields separate lists are given for these two purposes. The use of these letters will vary with the different methods of using the code. If normal cases are to be coded they are always listed as "1" in the proper field, followed by the proper letter to indicate the type of examination performed. (Example: Negative chest stereo. Dictated: "Six dash 1A." Written on report: VI-1A. Entered on score sheet by placing the patient's file number in the left-hand space of a horizontal column of the field VI sheet and placing A in vertical column 1.)

The coding of the examination type in an abnormal case is exactly similar, but uses column 2 instead of column 1 and is followed by the diagnosis code number. (Example: Fracture of the femur. Dictated: "Five dash 2C comma 3." Written on report: V-2C, 3. Entered on score sheet by placing patient's file number in the left-hand space of a horizontal column, C in vertical column 2, and a check mark in vertical column 3.) If the case is a follow-up examination and the fracture has previously been coded, the diagnosis number is followed by X. (The previous example would become: "Five dash 2C

comma 3X." V-2C, 3X. It would be scored as above, but an X would replace the check in column 3.)

Occasionally, even after the examination type has been coded, there is need for further localization of the disease process. This is accomplished by using the localizing letter in the diagnosis column. (Example: Ureteral calculus demonstrated by excretory pyelogram. Dictated: "Ten dash 2B comma 19C." Written: X-2B, 19C. Entered on score sheets by placing B in column 2 and C in column 19.)

If the examination types are omitted, the localization must be used more often. In the case of the femoral fracture previously cited, it would be necessary to use the localizing letter C following the diagnosis number. ("Five dash 3C." V-3C. Column 2 on the score sheet is left blank and C is entered in column 3.)

It is not necessary to use a localizing letter following the diagnosis number if the site of the lesion is explained either by the examination type or by the wording of the diagnostic category. (Example: Field I-7 refers specifically to clouding of the sinuses and no localizing letter is necessary even though the examination type is not being coded.)

It is suggested that fractures of ep[illegible] yseal portions of the long bones be lo[illegible] ized by the letter of the joint near wh[illegible] they occur instead of by the bone involv[illegible] This will separate them from fracture[illegible] the shaft.

Questionable diagnoses and cases of s[illegible] cial interest are emphasized by co[illegible] number 28 or 30 in addition to the diag[illegible] sis number.

The diagnostic category number "except as above," occurs in each f[illegible] This is a wastebasket category to inc[illegible] all the rare diagnoses not specific[illegible] listed. When "except as above" is use[illegible] should be followed by a simple statem[illegible] of the diagnosis to be written on the s[illegible] sheet. (Example: Esophageal vari[illegible] Dictated: "Nine dash 27 esophageal v[illegible] ices." Written IX–27 esophageal vari[illegible] A check mark is entered in column 2[illegible] Field IX and the words "esophageal v[illegible] ices" are written in the same horizo[illegible] column.) This procedure makes it [illegible] sible to locate rare cases quickly i[illegible] score sheets without having to devo[illegible] entire diagnostic category to each Since such diagnoses are infrequent, do not materially increase the clerical [illegible] in coding.

REVISED CODE FOR DIAGNOSTIC RECORDS

Field I: Bones of Face, Orbit, Mandible, Temporomandibular Joints, Sinuses, Mastoids, Teeth

1. Negative (Code examination type)
2. Abnormal (Code examination type. Do not code 2 if examination type is to be coded in another field.)

Bones of face, orbit, and mandible

3. Fracture
4. Deviation of nasal septum
6. Osteomyelitis

Sinuses

7. Clouding
8. Thickening of mucous membrane
9. Polyp, mucocele

Mastoids

11. Clouding
12. Thickening of cell walls
13. Sclerosis
14. Bone destruction
15. Cholesteatoma

Teeth

16. Impaction or other abnormal position
17. Caries
18. Periapical abnormality

20. Foreign body, soft tissue abnormality
21. Benign neoplasm
22. Malignant neoplasm, primary
23. Malignant neoplasm, secondary
24. Anomaly
25. Postoperative
26. Sinus tract
27. Except as above
28. Diagnosis questionable (Code probable [illegible] nosis also)
29. Unsatisfactory examination
30. Special interest

Examination type or localization (use localization when necessary)

A. Skull
B. Sinuses
C. Mastoids

Bones of face
Mandible
Temporomandibular joints
Orbit
Teeth

Except as above

w the diagnosis number by X if the diagnosis een coded on a previous examination.

Field II: Skull

Negative (Code examination type)
Abnormal (Code examination type. Do not code 2 if examination type is to be coded in another field.)

Fracture
Physiological calcification
Benign hyperostosis
Inflammatory disease of bone
Paget's disease, osteitis fibrosa cystica, hyperparathyroidism, osteopetrosis

nce of intracranial lesion

Sutural changes, accentuated convolutional markings, hydrocephalus
Intrasellar erosion
Extrasellar or parasellar erosion
Local bone changes, destructive or proliferative
Displacement of physiological calcification
Abnormal intracranial calcification
Unusual vascular markings suggesting intracranial lesion
Intracranial tumor, supratentorial
Intracranial tumor, infratentorial
Intracranial tumor, unspecified
Foreign body, soft-tissue abnormality
Benign neoplasm
Malignant neoplasm, primary
Malignant neoplasm, secondary
Anomaly
Postoperative
Sinus tract
Except as above
Diagnosis questionable (Code probable diagnosis also)
Unsatisfactory examination
Special interest

nation type or localization

Skull
Encephalogram
Ventriculogram

Except as above

the diagnosis number by X if the diagnosis en coded on a previous examination.

Field III: Spine

Negative (Code examination type)

2. Abnormal (Code examination type. Do not code 2 if examination type is to be coded in another field.)

3. Fracture
4. Abnormality of the intervertebral disk
6. Osteomyelitis
7. Paget's disease, osteitis fibrosa cystica, hyperparathyroidism, osteoporosis causing disability
9. Spondylolisthesis
10. Dislocation, subluxation
11. Epiphyseal separation
12. Osteochondritis (epiphysitis)
13. Spondylitis rhizomélique
14. Hypertrophic spondylitis
15. Trophic arthritis (Charcot joint, syringomyelia)
16. Arthritis, mechanical basis
17. Pott's disease
18. Abnormal alignment of the spine
20. Foreign body, soft tissue abnormality
21. Benign neoplasm
22. Malignant neoplasm, primary
23. Malignant neoplasm, secondary
24. Anomaly
25. Postoperative
26. Sinus tract
27. Except as above
28. Diagnosis questionable (Code probable diagnosis also)
29. Unsatisfactory examination
30. Special interest

Examination type or localization (Use localization only when necessary)

A. Cervical spine
B. Dorsal spine
C. Lumbar spine and sacrum
D. Dorsal and lumbar spine
F. Myelogram

P. Except as above

Follow the diagnosis number by X if the diagnosis has been coded on a previous examination.

Field IV: Upper Extremity. Field V: Lower Extremity

1. Negative (Code examination type)
2. Abnormal (Code examination type. Do not code 2 if examination type is to be coded in another field.)

3. Fracture, recent
4. Fracture, healing or healed
5. Fracture, non-union or malunion
6. Osteomyelitis
7. Paget's disease, osteitis fibrosa cystica, hyperparathyroidism, osteopetrosis, osteoporosis causing disability, osteogenesis imperfecta, metabolic bone change

8. Rickets, scurvy, lead line, congenital lues, achondroplasia
9. Ankylosis
10. Dislocation, subluxation
11. Slipped epiphysis, epiphyseal separation
12. Osteochondritis, osteochondritis dissecans, loose body
13. Arthritis, atrophic
14. Arthritis, hypertrophic
15. Arthritis, trophic, Charcot, syringomyelia
16. Arthritis, mechanical basis
17. Tuberculosis, bone or joint
18. Arthritis, purulent, septic, gonococcal
19. Arthritis, metabolic, gout, hemophilia, etc.
20. Foreign body, soft-tissue lesion
21. Benign neoplasm
22. Malignant neoplasm, primary
23. Malignant neoplasm, secondary
24. Anomaly
25. Postoperative
26. Sinus tract
27. Except as above
28. Diagnosis questionable (Code probable diagnosis also)
29. Unsatisfactory examination
30. Special interest

Examination type or localization. (Localize fractures of the diaphysis by the bone letter; of the metaphysis by the joint letter.)

Upper Extremity

A. Clavicle and sternoclavicular joint
B. Shoulder joint and scapula
C. Humerus
D. Elbow
E. Radius and ulna
F. Wrist
G. Hand
P. Except as above

Lower Extremity

A. Pelvis and sacro-iliac joint
B. Hip
C. Femur
D. Knee
E. Tibia and fibula
F. Ankle
G. Foot
P. Except as above

Follow the diagnosis number by X if the diagnosis has been coded on a previous examination.

Field VI: Thoracic Cage, Mediastinum, Soft Tissues of Neck, Cardiovascular System

1. Negative (Code examination type)
2. Abnormal (Code examination type. Do not code 2 if examination type is to be coded in another field.)

Thoracic cage

3. Fracture
4. Inflammatory disease of bone

Mediastinum

5. Non-specific inflammatory lymphade...
6. Abnormal thymus
7. Abnormal thyroid
8. Non-neoplastic abnormality of larynx
9. Mediastinitis, retropharyngeal ade... abscess
10. Lymphoblastoma (Code also under ...

Cardiovascular system

12. Pulmonary hyperemia, edema
13. Generalized cardiac enlargement
14. Characteristic contour of heart, a... pulsation
15. Pericardial effusion
16. Chronic adhesive pericarditis, calcifi... pericardium
17. Calcification, myocardium or heart va...
18. Aneurysm, luetic aortitis
19. Tortuous, elongated aorta, calcificat... aorta
20. Foreign body, soft tissue abnormality
21. Benign neoplasm
22. Malignant neoplasm, primary
23. Malignant neoplasm, secondary
24. Anomaly, including congenital heart dise...
25. Postoperative
26. Sinus tract
27. Except as above
28. Diagnosis questionable (Code probable... nosis also)
29. Unsatisfactory examination
30. Special interest

Examination type

A. Chest, stereo
B. Chest, single film
C. Chest, grid film
D. Chest, lateral or oblique
E. Chest, portable
F. Chest, thymus technic
H. Heart and aorta
I. Soft tissues of neck
J. Chest fluoroscopy
P. Except as above

Localization (use only when necessary)

A. Thoracic cage
B. Mediastinum
H. Heart and aorta
I. Soft tissues of neck
P. Except as above

Follow the diagnosis number by X if the di... has been coded on a previous examination.

d VII: Lungs and Pleura (Non-Tuberculous)

Negative (Code examination type)
Abnormal (Code examination type. Do not code 2 if examination type is to be coded in another field.)
Bronchopneumonia, primary atypical pneumonia
Lobar pneumonia
Abscess, suppurative pneumonitis
Pneumonia and pneumonitis, except as above (include fungus, sarcoid, tularemic, chronic fibroid pneumonia, etc.)
Bronchiectasis
Abnormal bronchogram other than bronchiectasis
Pulmonary emphysema, pneumonocele
Pneumoconiosis
Radiation fibrosis
Atelectasis
Pneumothorax, induced, spontaneous, traumatic
Tuberculosis, differential diagnosis only (Code 28 also)
Pleuritis without effusion
Pleural effusion, empyema
Foreign body, soft tissue abnormality
Benign neoplasm
Malignant neoplasm, primary
Malignant neoplasm, secondary
Anomaly
Postoperative
Sinus tract
Except as above
Diagnosis questionable. (Code probable diagnosis also)
Unsatisfactory examination
Special interest

ination type

Chest, stereo
Chest, single film
Chest, grid film
Chest, lateral or oblique
Chest, portable
Chest, thymus technic
Bronchogram
Soft tissues of neck
Chest fluoroscopy

Except as above

the diagnosis number by X if the diagnosis en coded on a previous examination.

Field VIII: Intrathoracic Tuberculosis

bnormal (Code examination type. Do not code 2 if examination type is to be coded in another field.)

alcified primary lesion, parenchymal
alcified primary lesion, lymph node

5. Non-calcified primary lesion, parenchymal or lymph node
6. Tuberculosis suspect, existence of lesion questionable
7. Minimal pulmonary tuberculosis
8. Moderately advanced pulmonary tuberculosis
9. Far advanced pulmonary tuberculosis
10. Inactive adult type lesion
11. Decision regarding activity not possible
12. Active adult type lesion
13. Progression
14. Regression
15. Atelectasis, tracheobronchial tuberculosis
16. Pneumothorax
17. Visceroparietal pleural adhesions
18. Pleuritis without effusion
19. Pleural effusion, empyema
20. Cavity
21. Cavity suspected
22. Miliary tuberculosis (Code also 3, 5, 10, 11, or 12)
23. Phrenic interruption
24. Thoracoplasty
25. Other surgical procedure
26. Sinus tract
27. Except as above
29. Unsatisfactory examination
30. Special interest

Examination type

A. Chest, stereo
B. Chest, single film
C. Chest, grid film
D. Chest, lateral or oblique
E. Chest, portable
F. Chest, thymus technic
J. Chest, fluoroscopy
P. Except as above

Follow the diagnosis number by X if the diagnosis has been coded on a previous examination.

Field IX: Gastro-Intestinal Tract

1. Negative (Code examination type)
2. Abnormal (Code examination type. Do not code 2 if examination type is to be coded in another field.)
3. Calcification within abdomen
4. Intestinal obstruction, paralytic ileus
5. Subphrenic or other peritoneal abscess, perforation of hollow viscus
6. Diaphragmatic hernia, eventration of diaphragm, paralysis of diaphragm
7. Extra-alimentary mass involving gut, neoplastic (code also) or inflammatory
8. Extra-alimentary mass not involving gut, neoplastic (code also) or inflammatory
9. Cardiospasm, pylorospasm, irritability of colon
10. Delay in gastric emptying
12. Cholecystogram, faint visualization

13. Cholecystogram, non-visualization
14. Abnormality of liver or spleen
15. Foreign body
16. Ulcer
17. Ulcerative colitis, including tuberculous and regional ileitis and colitis and lymphopathia venereum
18. Diverticulum
19. Calculus
20. Foreign body, soft tissue abnormality
21. Benign neoplasm
22. Malignant neoplasm, primary
23. Malignant neoplasm, secondary
24. Anomaly
25. Postoperative
26. Sinus tract
27. Except as above
28. Diagnosis questionable (Code probable diagnosis also)
29. Unsatisfactory examination
30. Special interest

Examination type

A. Abdomen
B. Complete G.I.; G.B.; colon and stomach
C. Stomach
D. Cholecystogram
E. Colon
G. Cholangiogram
P. Except as above

Localization (use only when necessary)

A. Esophagus
B. Stomach
C. Duodenum
D. Biliary tract
E. Colon
F. Small intestine
G. Diaphragm
P. Except as above

Follow the diagnosis number by X if the diagnosis has been coded on a previous examination.

Field X: Genito-Urinary Tract

1. Negative (Code examination type)
2. Abnormal (Code examination type. Do not code 2 if examination type is to be coded in another field.)

Genital Tract

3. Pregnancy
4. Obstetrically abnormal pelvis
6. Pelvic mass, ovarian cyst

Urinary Tract

7. Prostatic hyperplasia
8. Contracted or trabeculated bladder
9. Incomplete filling, pyelogram
10. Absence of kidney
11. Enlarged or contracted kidney
12. Abnormal position of kidney or ureter
13. Hydronephrosis
14. Hydro-ureter
15. Perinephritic abscess
16. Pyelonephritis, pyonephritis
17. Tuberculosis, renal, ureteral
18. Diverticulum
19. Calculus
20. Foreign body, soft tissue abnormality
21. Benign neoplasm
22. Malignant neoplasm, primary
23. Malignant neoplasm, secondary
24. Anomaly
25. Postoperative
26. Sinus tract
27. Except as above
28. Diagnosis questionable (Code probable diagnosis also)
29. Unsatisfactory examination
30. Special interest

Examination type

A. Abdomen
B. Excretory pyelogram
C. Retrograde pyelogram
D. Cystogram
E. Urethrocystogram
F. Uterogram
G. Pelvimetry
P. Except as above

Localization (use only when necessary)

A. Genital tract
B. Kidney
C. Ureter
D. Bladder
E. Urethra
F. Prostate
P. Except as above

Follow the diagnosis number by X if the diagnosis has been coded on a previous examination.

CONCLUSIONS

A revision of the Hodges and Lampe cross-index code for radiologic diagnosis is presented. If statistical review is not desired, the system may be simplified by leaving out examination types, normal cases, and follow-up examinations.

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Objectives and Radiological Aspects of Tuberculosis Control Program[1]

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HE CONTROL of tuberculosis has long been a serious medical problem. The blem has been particularly difficult be- se there is neither an effective immu- ng agent against nor a specific cure for disease. In recent years, efforts have n directed chiefly toward the discovery he sources of infection and the avoid- e of exposure to them. This will con- e to be the most important course of on until more decisive methods of con- are developed.

has been recently shown (1) that an tive program of tuberculosis control ld embrace four principal phases: case-finding, (*b*) medical care and iso- n, (*c*) aftercare and rehabilitation, and protection of the tuberculous family nst economic distress. A program h includes these public-health meas- , supported by research and well ned health education in each field of avor, will be certain to reduce the bidity and mortality from tuberculosis.

CASE-FINDING

ie purpose of a case-finding program is liscovery of the hidden cases of tuber- is. In general, such a program should irected toward those groups of the lation where a high prevalence of dis- is suspected and where large numbers e people can be reached quickly and omically. Until recent years case- ng efforts were centered primarily the families of known infectious patients. Since tuberculosis is basically a family epidemic, a high yield of new cases was obtained by this approach. However, limited field-nursing services and clinical facilities have greatly restricted the program except in those few communities with well developed and ample health services. Moreover, there are many tuberculous families scattered through the population in which the disease is completely unsuspected. It has been necessary, therefore, to supplement and complement these family epidemiological studies with other case-finding procedures.

Since the introduction of mass radiography, case-finding has been directed on an extensive scale to large population groups without reference to specific foci of infection. This type of program has been so satisfactory that many physicians have advocated that the entire population be examined radiographically at regular intervals. Such a scheme, however, is rather difficult and, furthermore, does not appear to be essential for the control of tuberculosis. As in the control of other communicable diseases, it is probably necessary to reach only a significant proportion of the population within a limited period of time.

There are two sizable segments of the population which may be easily reached by mass radiography, namely persons admitted to general hospitals and persons employed in the large and small industries of the nation.

Small-film radiography is well suited

[1] esented at the Joint Meeting of the American Roentgen Ray Society and the Radiological Society of North a, Chicago, Ill., Sept. 24–29, 1944.

to case-finding in general hospitals. No expense is entailed in assembling the people for study. In addition, film interpretation may be done by the staff of the department of roentgenology. Furthermore, facilities are already available for completing clinical examinations and providing care and treatment for ambulatory patients. The procedure also provides several valuable by-products. Increased accuracy in the clinical diagnosis of chest disease is obtained. Non-tuberculous disease is detected more quickly than before. Finally, and of particular importance, employees and nurses in contact with patients are spared unnecessary exposure to those who have tuberculosis in a communicable stage.

Hodges (2) at the University of Michigan Hospital, Ann Arbor, Childress *et al.* (3, 4) at Grasslands Hospital, New York, and Bloch and Tucker (5) at the University of Chicago Clinics and Provident Hospital, Chicago, have been examining routinely those admitted to their respective institutions for some time. In Michigan, where the photofluorographic process is employed, 9.3 per cent of the patients present abnormal roentgen findings; about 1.5 per cent exhibit x-ray evidence of pulmonary tuberculosis. In New York, where the fluoroscopic method is used, 2.8 per cent of the patients are found to have reinfection-type tuberculosis. In Chicago, where fluoroscopy and the sensitized paper method are employed, 1.3 per cent of the white patients and 2.64 per cent of the colored admissions give evidence of clinically active tuberculosis. From these figures, the value of mass radiography in the examination of admissions to general hospitals is evident.

It is hoped that soon all general hospitals will provide routine x-ray examinations of the chest just as they are now making routine serologic tests for syphilis. In 1943, over 15 million persons (6), not including outpatients, were admitted to general hospitals in the United States for care and treatment. The newly discovered cases of tuberculosis found among these patients can logically become the centers from which many other cases can be re-vealed.

The technical problems associated [illegible] the development of radiographic [illegible] finding programs in general hospitals [illegible] not be difficult. In small hospitals [illegible] less than 200-bed capacity, the numb[illegible] admissions is sufficiently low to p[illegible] the performance of the examination[illegible] department of radiology itself, [illegible] placing an excessive burden on th[illegible] ganization. An inexpensive photo[illegible] graphic unit may be installed to [illegible] the existing x-ray generating equipm[illegible] if the case-load is sufficiently small, [illegible] nations may be done with 14 × [illegible] films. In hospitals of greater than 2[illegible] capacity, a complete photofluorogr[illegible] installation (with its own x-ray gener[illegible] equipment) is usually required. In [illegible] instances, however, this equipment [illegible] not be expensive. Where the case-l[illegible] not great, units with hand-operated [illegible] eras may be employed. Installatio[illegible] be either in the department of radi[illegible] adjacent to the admitting office. [illegible] hospitals, completely automatic [illegible] fluorographs constituting an integ[illegible] of the admitting department are p[illegible] since they permit the examination [illegible] numbers of patients with a m[illegible] amount of effort.

Hospitals which care for the me[illegible] are also ideal centers in which to [illegible] mass radiographic methods. In the [illegible] States nearly 500,000 patients a[illegible] rently hospitalized in these insti[illegible] Chest surveys conducted in Mi[illegible] New York, and Illinois have sho[illegible] from 4 per cent to 10 per cent of th[illegible] tients have x-ray evidence of re[illegible] tuberculosis. These people are [illegible] likely to infect fellow patients and [illegible] stitutional members with whom th[illegible] in contact but, when released fro[illegible] can disseminate their disease to the [illegible] population.

The second population group i[illegible] mass radiographic procedures may [illegible] itably conducted consists of the m[illegible] industrial workers. From 1942 t[illegible]

r one million workers in the United tes were examined by eight transport- field units (35-mm. and 4 × 5-inch) he United States Public Health Serv- In this group of adults, 1.5 per cent e x-ray evidence of reinfection-type tu- :ulosis. Of these cases approximately er cent were minimal, 30 per cent mod- ely advanced, and 5 per cent far ad- ced, according to the classification of National Tuberculosis Association. s distribution is of considerable interest view of the fact that minimal cases prise only 10 to 15 per cent of the first issions to tuberculosis hospitals in this ıtry in recent years.

ther chest conditions besides tubercu- were frequently discovered by means nese industrial surveys. One per cent he films exhibited evidence of non- rculous pulmonary disease; about one- of these showed cardiac abnormalities. ımber of films gave evidence of unsus- ed cancer of the lungs, early enough many instances for operative inter- ion. Certainly no industrial hygiene ram can be considered complete unless e is included a routine chest x-ray ex- ıation of every employee prior to em- ment and at regular intervals there-

ıe United States Public Health Serv- which has recently been authorized he 78th Congress to expand its tuber- sis control program, plans to furnish ıcial assistance to state, city, and other h groups for the establishment of radiographic case-finding procedures, ıg the 15,000,000 persons admitted to al hospitals each year and among the ons of industrial workers; funds for ional clinics, nursing services, and atory facilities to complement this will also be provided. The Public h Service itself plans to operate ghout the United States only twenty x-ray units. These units will be used he purpose of demonstrating mass graphic technic and will be sent to lo- ommunities at the request of state ı departments. Each unit will consist of a medical officer, a public health nurse, two x-ray technicians and a record analyst, and complete equipment for mass radiography. It is hoped that these units will set high standards for tuberculosis control, act as local training centers, and in addition give actual service to the community.

In view of the present film shortage, it has frequently been asked what effect a national tuberculosis case-finding program has on current film supplies. A careful investigation reveals that many millions of people may be examined annually by mass radiographic methods (small sized survey films with 14 × 17-inch films in the positive cases) without requiring more than an extremely small fraction of the total civilian medical film production.

MEDICAL CARE AND ISOLATION

From a public-health standpoint, the primary purpose of sanatorium care is isolation of the patient to prevent spread of the disease. In addition, there is the opportunity to arrest the disease if it is not too advanced and to provide general physical restoration of the individual.

The full benefits of early diagnosis of pulmonary tuberculosis can be realized only if an adequate number of hospital or sanatorium beds are readily available for treatment of those with remediable disease and for isolation of the infectious patients. These institutions must be supplemented by well located chest clinics, generous public-health nursing services, accessible laboratory facilities, and the active participation of family physicians.

It is short-sighted to concentrate on case-finding if treatment is to be delayed because of a shortage of sanatorium beds. Once a program is started in a community, immediate plans must be made for providing a sufficient number of beds. Temporary facilities, including beds in general hospitals, should be utilized until tuberculosis hospitals are available.

At present, long periods of hospitalization are usually necessary for the care and treatment of tuberculous patients. As

mass radiography reaches larger numbers of the population, however, shorter periods of care will frequently be the rule, since many of the patients will have less extensive disease. If sufficient clinical facilities are established throughout the country, such persons, including those on collapse therapy, may often be transferred to the chest clinic for treatment and supervision. Others need only enter local convalescent homes.

In those unfortunately situated communities where no sanatoria or tuberculosis clinics are established, an attempt should be made to isolate known open cases in the home until such time as hospital facilities become available. The public-health nurse can play an important role by demonstrating simple methods of isolation and disinfection and by attempting to obtain examination of household contacts at frequent intervals.

AFTER-CARE AND REHABILITATION

Since tuberculosis often causes considerable disability, many persons who contract the disease must make an adjustment in their way of living when released from sanatorium care. This adjustment is not an easy one, and any guidance which can be given during the period of hospitalization will prepare the way for effective rehabilitation.

Soon after the tuberculous patient has entered the sanatorium he should have an opportunity to discuss with his physician the medical problems of his particular case so that an understanding of his condition may be acquired at an early date. As times goes on, further conferences will permit the establishment of an acceptable regime which may be followed not only during the days of hospitalization but in the period thereafter. During these discussions the question of the type of work which will be most suitable for the patient to follow will arise. In these conferences, the services of social workers, educational psychologists, and employment officers are essential in reaching a satisfactory choice. It is desirable that facilities be provided for instruction and training in the sele vocation as soon as the patient is medi and emotionally prepared.

Persons with arrested disease shoul returned gradually to full-time act through increasing part-time or mo employment. The Altro Worksho New York are good examples of this t of sheltered work. It is necessary to s sidize these workers during the peri partial employment in order to pr the family with sufficient income to a sist. Soviet Russia and Great Britain also carried out successful schemes sheltered work, particularly during critical first two years after discharge hospital care.

The disposition of patients with tious tuberculosis of a chronic presents a special problem. Such pa can be ambulatory and do some wor they must remain segregated becaus the communicability of their disease. English have arrived at a partial so through the Papworth and Presto Village Settlements. In Soviet Rus called night sanatoria provide partial cal supervision and regulated rest p for these persons. Segregated secti factories have sometime been desi for the employment of persons with c cally active disease. Small local shops in connection with well estab large sanatoria have also been ut These patients, of course, require s to supplement their limited income.

There is still another large group berculous persons who require ass for after-care. These include thos have received maximum benefits modern therapy but still have activ ease and therefore must remain is These persons can well be segreg local institutions and rest homes whe can be given at a minimum cost, fo protection of the health of the comm

Fundamentally the after-care an habilitation of the tuberculous p constitute low-cost insurance on th mendous investment of hospitali They are essential parts of a tuber

ntrol program and without them such a ogram falls short of its goal.

OTECTION OF THE TUBERCULOUS FAMILY AGAINST ECONOMIC DISTRESS

Tuberculosis is a community disease iich is important not only in terms of blic health but also from the point of w of national economy. Once the disse becomes advanced, the affected per1 is often disabled for life and dies a pre-ture death. The family, broken up by ig periods of disability or death of the eadwinner, almost inevitably is thrown on public resources for its support. Ac-dingly, a sound medical program must complemented by a generous plan of blic assistance, particularly for the iilies of the tuberculous poor. If this is done, full benefits will not be realized m the other phases of the program and ecially from sanatorium care.

t is no simple matter to provide institional isolation and treatment for all own infectious cases. The problem of ucing these persons to enter sanatoria l to remain there long enough to arrest ir disease or prevent its spread to others difficult one. If the breadwinner is the afflicted, his first concern is for the wel- of his family. Unless some provision nade to avoid economic disaster for dedents, physical disaster will eventually ill the tuberculosis sufferer who refuses ontinue hospitalization while his family n want. A national plan to provide quate protection against loss of wages ng treatment, and for several years af- urrest of the disease, is the only logical ver to this problem.

In order to achieve the four principal objectives of tuberculosis control, great assistance can be given by a carefully planned program of research in each of the fields of operation. Careful studies and investigations are indicated in the evaluation of present-day public health methods. Frequent inventories must be taken by state and local health departments to determine whether or not measures employed are actually decreasing mortality from the disease.

The application of new technical developments in mass radiography should greatly simplify the problem of case-finding among the population groups now difficult to reach. Mass radiography will make possible the epidemiological investigation of entire communities where only a small number of families could be studied before. This will give the epidemiologist an opportunity to study fundamental relationships in the evolution of pulmonary tuberculosis on an extensive scale.

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E D I T O R I A

Surveys for Tuberculosis

The recent appropriation by Congress of $10,000,000 for the extension of case-finding and the treatment of tuberculosis and the announcement of the plans of the United States Public Health Service for its use have stimulated discussion of tuberculosis surveys and their effect upon the "socialization" of medicine. The ideas expressed range from inordinate praise and optimism on the one hand to unjust objection and pessimism on the other. Judgment both as to the value of such surveys and their effect upon the "socialization" of medicine should be reserved until many aspects of the subject have been thoroughly considered and evaluated with regard to the whole program.

It seems inconceivable that any one interested in public welfare should object to surveys of the population for tuberculosis case-finding. Yet objections have been raised; some because the objectors do not consider surveys justifiable; some because the objectors fear an entering wedge for the government practice of medicine.

There is some basis for adverse criticism of the present hit-and-miss survey of small groups, but it is a short-sighted criticism. The surveys of school children represent a step in the right direction, but they do not reach the age group where investigation is most important. Surveys of the workers in a few factories are also useful, though they do not involve enough of the population to be really effective. Failure to cover the entire field is not, however, a valid reason for condemning group surveys.

The ideal survey would include all of the population in certain age groups annually. At the present time this seems impossible, because of inadequate equipment and personnel. It is, however, the objective toward which we should work. liable authorities have said that if univ surveys could be conducted, and follo treatment instituted, tuberculosis c be practically eradicated in ten y The difficulty in attaining this ideal i sufficient reason for abandoning it a objective.

A few metropolitan centers are a in a position to institute universal sur These could be used as test areas, fur ing accurate information as to the c the necessary personnel, the appa needed, etc. From these trial survey formation as to the requirements fo primary examination and follow-up tr ment could be gained. Information gathered would be invaluable in se up survey methods in other areas.

This experimental work must obv be done by a governmental agency, e Federal or state. In the interests of formity and success throughout the c try, the Federal Government is the logical supervising agency. The fear this will be an entering wedge for go mental medicine is no more real th fear that the state care of the ment will give rise to governmental me The nature of the disease makes care of the tuberculous patient nec Too few people are able to stand th nomic strain of a long period of illne convalescence. To provide sanator their care, we must look to the go ment, probably both state and Fe This means government administ of hospitals and government emplo of physicians. It is the only reas way to solve the problem. The me open tuberculosis in one's next-door bor, or in the worker at the next be

serious to be left to charity or unsys-
atic medical attention. The chief re-
ısibility of the medical profession is to
that the discovery and treatment of
ırculosis conform to proper medical
dards, not to political standards.
xperience has shown that where exten-
surveys for tuberculosis have been
e, the physician, both general and
ial, has benefited. Instead of losing
ents, he has gained them, not only new
ents with tuberculosis, but those with
r diseases disclosed by the survey. A
ey is not an accurate and complete
nostic measure. Because of its very
re, it hardly can be. It is, rather, a
owing process, after which come ac-
te study and diagnosis of the individual
. This becomes the job of the physi-
private for those who can afford his
ces, public for those who cannot take
of themselves. In either event, there
financial loss to the physician.
metimes the method of paying for
surveys has left an incorrect impres-
in the mind of the public regarding
ost of a chest film. The patient has
led to feel, because of the low unit cost in a survey, that the normal fee for a single examination of the chest by the private radiologist is unreasonably high. This is unfortunate and has sometimes worked to the disadvantage of the private radiologist. With proper publicity and education and proper methods of financing, this fault can be eliminated. The public is familiar with the reduction in costs brought about by mass production. They will be equally intelligent in realizing that the cost of a chest examination in a mass survey will be less than a private and more personalized study.

Group examinations for tuberculosis are of such fundamental importance to the public and individual health that they are coming in spite of the difficulties they present. Before they are completely satisfactory and successful, many trials and errors must be made. It is the duty of everyone concerned with their development to cooperate in every way to minimize the errors. Healthy development can be seriously hindered by attempts at dictation of policies and procedures by the government, social agencies, or professional groups.

SYDNEY J. HAWLEY, M.D.

RADIOLOGY SECTION
CALIFORNIA MEDICAL ASSOCIATION

Dr. James B. Irwin, of San Diego, has been elected Chairman of the Section on Radiology of the California Medical Association, and Dr. Gordon G. King, of San Francisco, Secretary.

THE PHILADELPHIA ROENTGEN RAY SOCIETY

The newly elected officers of the Philadelphia Roentgen Ray Society are: President, Dr. Paul C. Swenson; Vice-President, Dr. Louis Edeiken; Treasurer, Dr. David A. Sampson; Secretary, Dr. Calvin L. Stewart.

Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

Pulmonary Tuberculosis in the Adult: Its Fundamental Aspects. By Max Pinner, M.D., Chief, Division of Pulmonary Diseases, Montefiore Hospital for Chronic Diseases, New York; Editor, American Review of Tuberculosis; Clinical Professor of Medicine, College of Physicians and Surgeons, Columbia University, New York. A volume of 579 pages, with 59 illustrations and graphs. Published by Charles C Thomas, Springfield, Ill. Price $7.50.

Book Reviews

Supervoltage X-Ray Therapy: A Report for the Years 1937–1942 on the Mozelle Sassoon Supervoltage X-Ray Therapy Department, St. Bartholomew's Hospital. By Ralph Phillips, M.S., M.B., F.R.C.S., D.M.R.E., Sir Halley Stewart Fellow, with the technical assistance of G. S. Innes, B.Sc., A.M.I.E.E., Physicist to the Mozelle Sassoon Department. With a Foreword by The Rt. Hon. The Lord Horder, G.C.V.O., M.D., F.R.C.P. A volume of 142 pages, with 95 illustrations. Published for The Sir Halley Stewart Trust by H. K. Lewis & Co., Ltd., London, 1944. Price 16*s.* net.

The author has written a monograph on the experience of St. Bartholomew's Hospital, with a million-volt x-ray machine, from 1937 to 1942, inclusive. It is one of the first books, if not the first, dealing exclusively with supervoltage equipment, physical measurements, and clinical observations.

Considerable space is allotted to a detailed des[illegible] tion of the supervoltage x-ray machine design[illegible] installed by Messrs. Metropolitan Vickers Elec[illegible] Co., Ltd. Various parts of the x-ray mach[illegible] well illustrated with photographs and dr[illegible] The descriptions and illustrations should be [illegible] while for those building supervoltage x-ray [illegible] chines. The one showing a filament holder c[illegible] six interchangeable filaments is interesting.

The building housing the supervoltage [illegible] machine is described and illustrated. It w[illegible] esting to note that the walls were so sturdy th[illegible] damage was done by bombs dropped nearby.

Physical measurements are illustrated by [illegible] and curves. Isodose curves are given for [illegible] qualities of supervoltage radiation.

Clinical investigations to determine the [illegible] of roentgens to produce a unit skin dose ([illegible] are described. The treatment of various ty[illegible] lesions is illustrated with corresponding i[illegible] curves showing the percentage of radiation de[illegible] to the tumor-bearing area. The number of pa[illegible] treated and the corresponding life spans ar[illegible] sented.

In conclusion: The book contains useful i[illegible] tion for anyone anticipating supervoltage th[illegible] The clinical application in the use of isodose c[illegible] number, size and direction of portals with total [illegible] doses, will be of interest to the general radi[illegible] and worth while for reference.

Les bases physiques et biologiques de la r[illegible] genthérapie. By Paul Lamarque, Do[illegible] ès Sciences, Professeur à la Faculté de Mé[illegible] de Montpellier, Directeur du Centre R[illegible] contre le Cancer. With the collabora[illegible] Pierre Bétoulières, Ancien Interne des [illegible] taux, Chef de Laboratoire de Radiolog[illegible] Faculté de Médecine de Montpellier, Je[illegible] boul, Docteur ès Sciences, Chef de Lab[illegible] de Radiologie à la Faculté de Médecine de [illegible] pellier, Edmond Debains, Ingénieur E[illegible] and Pierre Lorimy, Ingénieur E.S.E. Pr[illegible] Professeur Strohl, Membre de l'Acad[illegible] Médecine. A volume of 530 pages, with [illegible] ous illustrations. Published by Masson [illegible] Ed., Paris.

This volume of 530 pages, well printed [illegible] paper, is a comprehensive and competent w[illegible] is well illustrated with good line drawings [illegible] material on basic physics, written in coll[illegible] with Reboul, is handled with a minimum of [illegible] matics, but contains considerable theoretic[illegible] rial, presented in lucid fashion. The sec[illegible] x-ray tubes and generators, in collaborat[illegible] Lorimy and Debains, is quite complete.

e chapter on qualitative measurements of x-
is excellent, containing data on spectrometry,
t and indirect voltage measurement, and the
us schemes dependent on absorption measure-
s. In the chapter on quantitative measure-
s and practical dosimetry, most of the stand-
dosimeters are described in some detail. A
deal of material is given for the determination
e surface dose, but very little for depth doses.
: additional curves and tables are included in a
chapter, but nowhere does one find enough
rial for practical dosage calculations.

e section devoted to biological effects contains
led discussions of reversible and irreversible,
and late effects, radiosensitivity, time and in-
:y and quality factors. Bétoulierès in his chap-
ıfter describing the response to radiation of
us tissues and organs, outlines theories of the mechanism of action of radiation. Reboul, in his, goes into considerable detail regarding the various theories of action of a given dose of radiation, first on a biologic population and second on a single cell.

Under therapy technics, a good deal of space is devoted to very low and very high voltages, but little to the region most commonly available. The section on time factor and fractionation of dose should be considered a historical review of the subject; it presents a group of methods, taken from the literature and disagreeing somewhat among themselves, without critical discussion.

The chapters on radiological accidents and protection are thorough, including the French official regulations.

The book concludes with a bibliography of 651 items and an extensive table of contents. Unfortunately there is no index.

RADIOLOGICAL SOCIETIES OF NORTH AMERICA

Editor's Note.—Will secretaries of societies please co-operate by sending information to Howard P. Doub, M.D., Editor, Henry Ford Hospital, Detroit 2, Mich.

UNITED STATES

Radiological Society of North America.—Secretary, D. S. Childs, M.D., 607 Medical Arts Bldg., Syracuse 2, N.Y.

American Roentgen Ray Society.—Secretary, Harold Dabney Kerr, M.D., Iowa City, Iowa.

American College of Radiology.—Secretary, Mac F. Cahal, 20 N. Wacker Dr., Chicago 6, Ill.

Section on Radiology, American Medical Association.—Secretary, U. V. Portmann, M.D., Cleveland Clinic, Cleveland 6, Ohio.

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San Francisco Radiological Society.—Secretary, Carlton L. Ould, University Hospital, Medical Center, San Francisco 22. Meets monthly on the third Thursday at 7:45 P.M., first six months of the year in Lane Hall, Stanford University Hospital, and second six months in Toland Hall, University of California Hospital.

COLORADO

Denver Radiological Club.—Secretary, A. Page Jackson, Jr., M.D., 304 Republic Bldg., Denver 2. Meetings third Friday of each month, Denver Athletic Club.

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Illinois Radiological Society.—Secretary-Treasurer, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—Secretary, Frank S. Hussey, M.D., 250 East S[illegible] St., Chicago 11.

INDIANA

The Indiana Roentgen Society.—Secretary-T[illegible] Harold C. Ochsner, M.D., Methodist Hospital, [illegible]apolis 7. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Secretary, Arthur W. [illegible] M.D., Suite 326 Higley Building, Iowa City. [illegible] luncheon and business meeting during annual [illegible] of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—Secretary-Tr[illegible] Sydney E. Johnson, 101 W. Chestnut St., Lo[illegible]

LOUISIANA

Louisiana Radiological Society.—Secretary-Tr[illegible] Johnson R. Anderson, M.D., North Louisi[illegible] tarium, Shreveport. Meets annually at sa[illegible] State Medical Society.

Shreveport Radiological Club.—Secretary, O[illegible] Jones, M.D., 2622 Greenwood Road. Meets [illegible] September to May, third Wednesday, 7:30 P.M.

MARYLAND

Baltimore City Medical Society, Radiological Se[illegible] Secretary, Charles N. Davidson, M.D., 101 W[illegible] St., Baltimore 1.

MICHIGAN

Detroit X-ray and Radium Society.—Secretary-Tr[illegible] E. R. Witwer, M.D., Harper Hospital, Detroit 1[illegible] ings first Thursday of each month from Octobe[illegible] at Wayne County Medical Society club r[illegible]

Michigan Association of Roentgenologists.—S[illegible] Bruce MacDuff, M.D., 201 Sherman Bldg., F[illegible]

MINNESOTA

Minnesota Radiological Society.—Secretary, [illegible] Stenstrom, M.D., Minneapolis General Ho[illegible] neapolis 26. Meetings quarterly.

MISSOURI

Radiological Society of Greater Kansas City.—S[illegible] John W. Walker, M.D., 306 E. 12th St., Ka[illegible] Mo. Meetings last Friday of each month.

St. Louis Society of Radiologists.—Secretary, [illegible] Ernst, M.D., 100 Beaumont Medical Bldg. [illegible] fourth Wednesday of each month except J[illegible] August, and September.

NEBRASKA

Nebraska Radiological Society.—Secretary-T[illegible] Donald H. Breit, M.D., University of Nebr[illegible] pital, Omaha 5. Meetings third Wednesday [illegible] month at 6 P.M. in either Omaha or Lincoln.

NEW ENGLAND

New England Roentgen Ray Society.—Secretary-T[illegible] George Levene, M.D., Massachusetts Me[illegible]

ls, Boston, Mass. Meets monthly on third Friday .oston Medical Library.

NEW HAMPSHIRE

Hampshire Roentgen Society.—Secretary-Treasurer, .ard C. Batt, M.D., St. Louis Hospital, Berlin.

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iological Society of New Jersey.—Secretary, H. R. .dle, M.D., 501 Grand Ave., Asbury Park. Meet- at Atlantic City at time of State Medical Society midwinter in Newark as called.

NEW YORK

ciated Radiologists of New York, Inc.—Secretary, am J. Francis, M.D., East Rockaway, L. I.

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alo Radiological Society.—Secretary-Treasurer, ph S. Gian Franceschi, M.D., 610 Niagara St., alo 1. Meetings second Monday evening each th, October to May, inclusive.

al New York Roentgen Society.—Secretary-Treasurer, on F. Potter, M.D., 425 Waverly Ave., Syracuse Meetings in January, May, and October.

Island Radiological Society.—Secretary, Marcus ner, M.D., 1430 48th St., Brooklyn 19. Meetings th Thursday evening each month at Kings County ical Bldg.

York Roentgen Society.—Secretary, Wm. Snow, ., 941 Park Ave., New York 28.

ester Roentgen-Ray Society.—Secretary, Murray P. ge, M.D., 260 Crittenden Blvd., Rochester 7. s at Strong Memorial Hospital, third Monday, ember through May.

NORTH CAROLINA

ological Society of North Carolina.—Secretary- surer, Major I. Fleming, M.D., 404 Falls Road, y Mount. Meets in May, and October.

NORTH DAKOTA

Dakota Radiological Society.—Secretary, Charles nan, M.D., 1338 Second St., N., Fargo.

OHIO

Radiological Society.—Secretary, Henry Snow, , 1061 Reibold Bldg., Dayton 2. Next meeting at al meeting of the Ohio State Medical Association.

and Radiological Society.—Secretary-Treasurer, D. Brannan, M.D., 11311 Shaker Blvd., Cleveland Meetings at 6:30 P.M. on fourth Monday of each h from October to April, inclusive.

logical Society of the Academy of Medicine (Cin- i Roentgenologists).—*Secretary-Treasurer,* Sam- rown, M.D., 707 Race St., Cincinnati 2. Meet- eld third Tuesday of each month.

PENNSYLVANIA

ylvania Radiological Society.—Secretary-Treasurer, Wurster, M.D., 416 Pine St., Williamsport 8. ociety meets annually.

lelphia Roentgen Ray Society.—Secretary, Calvin wart, M.D., Jefferson Hospital, Philadelphia 7. first Thursday of each month at 8:00 P.M., from er to May, in Thomson Hall, College of Physi- 21 S. 22d St.

Pittsburgh Roentgen Society.—Secretary-Treasurer, Lester M. J. Freedman, M.D., 4800 Friendship Ave., Pittsburgh 24. Meets second Wednesday of each month at 6:30 P.M., October to May, inclusive, at The Ruskin, 120 Ruskin Ave.

ROCKY MOUNTAIN STATES

Rocky Mountain Radiological Society (North Dakota, South Dakota, Nebraska, Kansas, Texas, Wyoming, Montana, Colorado, Idaho, Utah, New Mexico).—*Secretary,* A. M. Popma, M.D., 220 North First St., Boise, Idaho.

SOUTH CAROLINA

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Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—Secretary-Treasurer, J. Marsh Frère, M.D., 707 Walnut St., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Dallas-Fort Worth Roentgen Study Club.—Secretary, X. R. Hyde, M.D., Medical Arts Bldg., Fort Worth, Texas. Meetings on third Monday of each month, in Dallas in the odd months and in Fort Worth in the even months.

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WISCONSIN

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University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 414 N. Charter St., Madison 6. Meets first and third Thursdays, 4 to 5 P.M., September to May, inclusive, Room 301, Service Memorial Institute.

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La Société Canadienne-Française d'Electrologie et de Radiologie Médicales.—General Secretary, Origène Dufresne, M.D., Institut du Radium, Montreal. Meets on third Saturday of each month.

CUBA

Sociedad de Radiología y Fisioterapia de Cuba.—Offices in Hospital Mercedes, Havana. Meets monthly.

ABSTRACTS OF CURRENT LITERATURE

ROENTGEN DIAGNOSIS

The Chest

The Digestive System

The Peritoneum

The Spleen

The Skeletal System

Gynecology and Obstetrics

The Genito-Urinary Tract

RADIOTHERAPY

Neoplasms

THE CHEST

X-Ray Diagnosis of Retrocardial and Retrodiaphragmatic Infiltrations of the Lungs. Nils P. G. Edling. Acta radiol. 23: 595-602, December 1942. (In German.)

The author discusses the roentgen diagnosis of retrocardiac and retrodiaphragmatic densities of the lungs, proceeding from a study of cases of bronchopneumonia.

In technically perfect frontal roentgenograms retrocardiac shadows may be observed. Retrodiaphragmatic shadows can be seen in lateral or oblique views or in posterior-anterior views if the beam is directed tangentially toward the posterior part of the diaphragmatic dome. The importance of studying the contour of the pneumo-pleural demarcation line in order to detect slight densities is stressed. A break in the continuity of this line is pathologically significant.

MAX SGALITZER, M.D.

Disqualifying Pulmonary Defects in 100,000 Selectees Examined Radiographically by an Armed Forces Induction Station. Miner W. Seymour. Ohio State M. J. 40: 1041-1045, November 1944.

The findings in 100,000 chest roentgenograms of recruits from southern Ohio are summarized. The total number of men rejected in this series for pulmonary conditions was 2,505 (2.4 per cent); 2,002 (2 per cent) of this number had tuberculous lesions. Sixty-four men (0.06 per cent) had what was considered a possible active primary focus; 427 (0.43 per cent) had stable primary residuals which were too extensive for induction under existing regulations. One per cent of the men examined had reinfection phase tuberculosis in some stage; 0.87 per cent had minimal lesions whose activity was undetermined, and 0.13 per cent advanced disease with cavitation or honeycombing. The three leading non-tuberculous conditions necessitating rejection were bronchiectasis (128), thickened pleura (95), and silicosis (68).

The first 68,045 roentgenograms included in this study were taken on 14 × 17-in. single paper film. The film was read wet by reflected light arranged so as to prevent glare and surface reflection. A tube-screen distance of 48 inches was used, with the following technical factors: 100 ma., 70-90 kv.p., and 0.1-0.15 sec. This gave good penetration and contrast for all except the heaviest men. The remaining 31,995 films were taken by a photoroentgen unit as 4 × 5-in. stereo-pictures on 4 × 10-in. film. Of several technics, the one finally adopted was as follows: 36-in. tube-screen distance, 150 ma., 80-100 kv.p., 0.2 to 0.3 sec. Any extremely thick man (over 28 cm.) was x-rayed on 14 × 17-in. single film to conserve the tube life of the photoroentgen unit. Retakes with the paper film averaged 3 per 100; with the stereoscopic films, 2 per 100. Approximately 125 to 140 men per hour could be examined with the first method; 65 to 75, with the latter. The diagnostic value of both types of film is good, although the stereoscopic image has some advantage over the flat plate. The paper film has the disadvantage of being bulky to file.

Primary Atypical Pneumonia of Unknown Eti[illegible] Sven Gundersen. New England J. Med. 231: 69[illegible] Nov. 23, 1944.

This is a review of 122 carefully studied cases [illegible] nosed as atypical pneumonia. The condition is [illegible] acterized by the influenza-like symptoms of mild [illegible] respiratory tract infection, with few physical fi[illegible] which are slow in appearing and mild as compared [illegible] the roentgen findings.

The therapy is symptomatic. Sulfonamides [illegible] influence the course of the disease. Roentgen [illegible] is advised, but was not used in this series.

Two cases terminated fatally and came to a[illegible] and the findings are described.

The possibility of confusion with tuberculosis i[illegible] sidered and cautioned against.

JOHN B. MCANENY, M[illegible]

Congenital Lung Cyst Complicated by [illegible] thorax. M. J. Carson and A. Webb, Jr. J. Pedi[illegible] 443-446, November 1944.

A case of congenital lung cyst complicated by [illegible] pneumothorax is reported in a 2 1/2-month-old [illegible] male, who had been well until approximately [illegible] minutes before admission. The infant was we[illegible] veloped and well nourished but in obvious [illegible] distress, with a rapid, grunting type of respira[illegible] The right chest appeared larger than the left [illegible] showed a definite respiratory lag. The heart [illegible] shifted to the left, the rate was rapid, and the rhy[illegible] regular. The percussion note over the entire [illegible] chest was hyperresonant and the breath sound[illegible] were extremely faint. A spontaneous pneumot[illegible] was believed to be present, and sulfadiazine was [illegible] prophylactically. A roentgenogram two days [illegible] showed a right-sided pneumothorax, with the [illegible] shifted to the left, evidence of fluid at the base, a[illegible] large cavity at the right apex, apparently in the [illegible] stance of the lung. During the next three days th[illegible] fant seemed to improve, but on the fourth day, he [illegible] denly began to breathe with great difficulty, went [illegible] shock, and became stuporous. A thoracentesis wa[illegible] mediately performed. A fair amount of air, [illegible] high pressure, was removed, together with 40 c[illegible] straw-colored fluid, which on culture revealed [illegible] lytic *Staphylococcus aureus*. Respiration ceased [illegible] stimulants and artificial respiration were re[illegible] Blood transfusions and fluids were then given, a[illegible] sulfadiazine increased. On the sixth day, 40,000 [illegible] *Staphylococcus* antitoxin were given intramusc[illegible] followed by 20,000 units the next day, and improv[illegible] was noticeable. A second thoracentesis yielded [illegible] bloody pus, from which hemolytic *Staphylococ[illegible] reus* was again isolated. On the eleventh day, a [illegible] drain was inserted in the right chest between the [illegible] and seventh ribs in the posterior axillary line a[illegible] pus was obtained. Irrigations were carried out [illegible] daily. Following this there occurred a steady de[illegible] in the amount of drainage, with an increase in ap[illegible] a gain in weight, and some clearing of the ch[illegible] shown by roentgenograms and physical examin[illegible] Sulfadiazine was discontinued one month aft[illegible] mission, and two days later the patient began to [illegible] persistently and to vomit frequently, the vomitus [illegible]

ally containing blood-streaked purulent material. entative diagnosis of bronchopleural fistula was le; a rib resection was performed and open drain- of the right chest instituted. Following this, there rapid improvement, with gradual diminution of the of the cavity and of the amount of drainage. The ent was discharged on the eighty-second hospital . A roentgenogram of the chest, taken approxi- ely three months after the onset of the illness, ved practically complete healing and closure of the yema cavity. The cyst was still prominent at the t apex, apparently unchanged in size or shape.

ung Abscess. Pathology and Diagnosis of Certain es. N. R. Barrett. Lancet 2: 647–651, Nov. 18, t.

ive varieties of lung abscess which are sufficiently to type to warrant separate consideration are de- ed.

olitary Putrid Lung Abscess. Putrid abscess is the lt of the inhalation of infected matter into the ter- al bronchioles of a bronchopulmonary segment, the t cause being certain anaerobic organisms in the chial embolus. Once infected material has become cted in the terminal radicles of the bronchial tree, e is a latent period before the disease is manifest. lesion which develops in the lung is one of acute tive gangrene. At first it involves a part of one chopulmonary segment; in this limited area the chioles and their accompanying blood vessels are royed and the intervening tissues are liquefied. inflammation fans out toward the surface of the and the pleura is soon involved, thus producing sions over the abscess which prevent its rupture the pleural space. By about the tenth day a soli- cavity has formed, with an average diameter of inches. This cavity is peculiar in that it contains cted sloughs of lung, as well as foul pus, debris, organisms; its walls are granulation tissue forming e of demarcation exactly like that seen in gangrene e extremities. Beyond the cavity the whole of the chopulmonary segment concerned is in a state of e vascular engorgement and edema.

ne onset of the illness is sudden, resembling an at- of influenza with pleural pain. Within a few days picture is more like that of lobar pneumonia. Dur- the first seven to ten days there is little cough or um, because the lesion has not yet excavated, but t this time the patient may notice a bad taste in mouth and perhaps a little blood-stained expectora- Suddenly, the sputum becomes purulent, abun- and grossly offensive. Roentgenograms taken the end of the second week of the illness may a cavity with a fluid level in an area of consolida- Such a cavity can be seen in only half of the and failure to demonstrate it roentgenographi- does not rule out its presence.

ath is unusual in the first fortnight of the illness, ccurs if the gangrenous process is not localized. ule, subsequent events are governed by the estab- ent, or not, of bronchial channels adequate to away the sloughs and other cavity contents. third of all cases such drainage takes place spon- usly. Reliable statistics show (1) that it is im- le to predict which acute abscesses will resolve aneously, except by observing the lesion for a period; (2) that the majority of spontaneous cures within three months of the onset of symptoms; (3) that the mortality, with treatment of any kind, increases as time passes.

Aerobic Lung Abscess. The first pathological change in the lungs in aerobic abscess is a diffuse bronchopneumonia of unusual type. Small foci of consolidation appear over a wide area in contrast with the early segmental distribution of putrid abscess. As time passes, some of the consolidated areas resolve, some become organized and may be replaced by fibrous tissue, and some suppurate and progress to abscess formation. The foci of pneumonia may be bilateral and spread slowly from one part of the lung to another, so that healing and progress are present together, but there is a general tendency for the lesions to remain in a state of non-resolution. The abscesses are at first small and scattered; the majority discharge their quota of pus into the bronchial tree and heal spontaneously, but in some cases the lesion is more circumscribed, the peribronchial collections of pus coalesce, and large abscess cavities are formed. These are generally loculated and of more irregular shape than putrid abscesses, but clinically differentiation may be impossible. The cause of aerobic abscess is not known, but the organisms in the sputum and in the lung cavities are not anaerobes.

The onset of symptoms is often rather insidious, with lassitude, dyspnea on exertion, an unproductive cough, and pyrexia. The physical signs and the early x-ray findings are typical of bronchopneumonia, but the unusual course of events may suggest pulmonary tuberculosis or neoplasm. The fact that the sputum is not foul is regarded by many as the most significant difference between aerobic and putrid abscess, but the latter may be so well shut off from the bronchial tree that the patient may not discern the characteristic odor. The course of aerobic abscess is rather protracted, but the outlook is better than in putrid abscess. The abscess is merely an incident in the course of a peculiar type of bronchopneumonia and, as such, its presence is relatively unimportant. Surgical measures, such as drainage, are not likely to produce the same dramatic amelioration of symptoms as in putrid abscess.

Staphylococcal abscesses warrant separate consideration because they are often blood-borne, or at least associated with a septicemia, may be affected by such substances as penicillin, and rarely, if ever, require surgical drainage. A staphylococcal abscess may develop either as a complication of staphylococcal pneumonia or as part of a pyemia or septicemia. In both varieties there are pleural complications of great interest and importance. Small cavities situated upon the surface of the lung are apt to perforate into the pleural space and produce spontaneous pneumothorax, tension pneumothorax, and empyema.

The diagnosis of staphylococcal pulmonary abscess depends chiefly upon demonstrating the organism in pure culture in the blood, or in practically pure culture in the sputum, the abscess cavity, or the pleural fluid. The x-ray appearance of the lesions in the chest is so characteristic that many consider it pathognomonic. The opacities are widespread and dense, with rather indefinite outlines: they are often disposed throughout the lungs, and their size and extent immediately suggest a hopeless prospect. Rapid resolution can take place, however. Large cavities are often seen; they are generally empty, or at best partly filled with fluid. During the period of resolution the cavities may persist for a long time as "ring shadows" and can be mistaken for cysts.

Bronchial Abscess. The term bronchial abscess is used to describe a lesion which arises acutely as a result of bronchial occlusion by a relatively large foreign body, such as a tooth. Atelectasis occurs in the affected segment and the bronchi peripheral to the block are at first reduced in caliber. Within a short time mucus and inflammatory fluid collect within these bronchi and infection produces a purulent exudate. It is this intrabronchial collection of pus which is called a "bronchial abscess." If the foreign body is removed, the process settles down and the tissues return to normal. The x-ray appearance is that of atelectasis; the foreign body may or may not be apparent.

Suppurating hematoma of the lung is not well defined but for practical purposes a hematoma is an extravasation of blood of such an extent that it can be diagnosed radiologically. The lesion may result from crush injuries, blast injuries, and penetrating wounds, the blood disrupting the interstitial tissues and lying in the alveoli and bronchi. Organization occurs without cavity formation in most cases and the affected area passes through a phase in which the macroscopic appearance is identical with the gray hepatization of lobar pneumonia. Microscopy, however, shows that the predominating cells are monocytes and not polymorphonuclears. If infection takes place at this stage, a lung abscess forms. The diagnosis is confirmed by blood-stained purulent sputum and by a roentgenogram showing a cavity with a fluid level. The great majority of suppurating hematomas resolve spontaneously and healing is complete.

Unusual X-Ray Findings in a Case of Pedunculated Pulmonary Fibroma. L. Billing. Acta radiol. 23: 592–594, Dec. 15, 1942. (In German.)

The author reports the x-ray findings in a case of pulmonary fibroma, the size of a child's head, fixed by a peduncle to the left upper lobe of the lung. On changes in the position of the patient, the tumor showed marked motility within the pleural cavity.

MAX SGALITZER, M.D.

Health Hazards Associated with the Welding Process. Report of Cases and Review of Recent Literature. Robert W. Quinn. Mil. Surgeon 95: 410–419, November 1944.

Six patients with similar acute symptoms of short duration, in an East Coast Navy Yard, were all found to have been exposed to welding fumes, and a diagnosis of metal fume fever was made. The author gives a brief account of his observations and reviews the entire subject of welding injuries, presenting a comprehensive bibliography. X-ray changes may occur in the lungs, closely resembling those of silicosis [see, for example, abstracts of papers by Jones and Lockhart and Sander in Radiology 43: 405, 1944], but no roentgen studies seem to have been made in the author's patients.

Post-Operative Chest Complications in Gastric Surgery. T. W. Mimpriss and F. G. Etheridge. Brit. M. J. 2: 466–468, Oct. 7, 1944.

The author presents an interesting discussion of chest conditions following gastric surgery. The gastric lesions are grouped under four headings: (1) ulcers without previous surgery; (2) ulcers with previous ineffective surgery; (3) acute gastric hemorrhage; (4) gastric carcinoma. The pulmonary complications described include acute bronchitis, lobar atelectasis, and lobular or patchy atelecta[illegible] series of 34 cases, 29 were in the last clas[illegible] these ended fatally. These 4 cases are revie[illegible] tail.

The chief etiologic factor in chest complic[illegible] gastric surgery is severe peritoneal [illegible] Other factors, *i.e.*, the postoperative conditi[illegible] patient and sex and seasonal incidence, are [illegible] The principal preventive measure is proper a[illegible] the lungs by respiratory activity and moveme[illegible] patient postoperatively. Where inflammati[illegible] lung has already set in, the usual course for [illegible] is advised.

Q. B. CORAY, M.D.

Mega-Esophagus as a Cause of Mediastinal [illegible]ing. Allan Hurst and Sydney Bassin. Am. J. [illegible]genol. 52: 598–606, December 1944.

As a result of routine mass surveys of the ch[illegible] primarily for the detection of pulmonary tub[illegible] numerous other lesions are being found, the [illegible] of which may result in corrective measures of [illegible] the individual. One of these lesions is mega-es[illegible] or cardiospasm. Eleven cases are reported [illegible] this condition was discovered on routine che[illegible] genograms and later proved by barium-meal [illegible] The significant changes which lead to a diag[illegible] mega-esophagus are as follows:

(1) Diffuse widening of the mediastinum, [illegible] beginning at the thoracic inlet or just below.

(2) Fluid level. This was seen in 4 of the [illegible] 11 cases at the level of the clavicles. Its pres[illegible] pended upon recent eating, drinking, and sw[illegible] of air.

(3) Stippling. The upper part of the sh[illegible] show a stippled or mottled appearance due to a [illegible] of air and food in the dilated esophagus.

(4) Apparent widening of the cardiac contour [illegible] protrusion of the esophagus beyond the right [illegible] With greater penetration a double margin may [illegible]

(5) Obliteration of the cardiophrenic angle.

When these signs are present, mega-esophagus [illegible] be suspected and complete barium meal studies [illegible] be done.

L. W. PAUL, M.D.

Roentgen Studies of the Heart in Asthmatic Ch[illegible] V. J. Derbes and H. T. Engelhardt. J. Pe[illegible] 394–399, November 1944.

Physical and x-ray examinations were carried [illegible] 12 asthmatic children to determine the presen[illegible] sence of cardiac hypertrophy. The standard [illegible] of estimating the heart size from roentgen stu[illegible] employed. After a preliminary fluorosc[illegible] meter plates were taken. The transverse, lo[illegible] and broad diameters of the heart and the [illegible] observations were within normal limits in [illegible] Prediction formulae for the transverse diamet[illegible] heart using height and weight ([*a*] T = 0.0[illegible] 7.5; [*b*] T = 0.00490H + 0.05694W + [illegible] worked out, and the results showed a close cor[illegible] with the actual measurements. With but thre[illegible] tions, the actual transverse diameter was less [illegible] predicted diameter, and in these the differe[illegible] minimal. The transverse diameter obtained [illegible] cardiothoracic ratio of Danzer was well with[illegible] limits in each case. The figures for the card[illegible] as determined by the Eyster-Hodges nomogram [illegible] by computation were, for the most part, in clo[illegible] ment.

...e authors conclude that uncomplicated bronchial ...a is not a factor in heart disease. This does not ...te against the production of heart disease subse- ...to pulmonary fibrosis, emphysema, bronchiecta- ...nd other pulmonary complications seen in the ...ie asthmatic state.

...ical and Roentgen Manifestations of Dissecting ...ysm of the Aorta. Max Ritvo and Paul J. Votta. ... Roentgenol. **52:** 583–594, December 1944.

...issecting aneurysm is not a true aneurysm in that ...men of the vessel is not increased. It is produced ...netration of the circulating blood between the ...of the wal of the vessel and is usually associated ... tear in the intima of the artery, hypertension, ...heroselerosis.

...ecting aneurysm of the aorta is rarely diagnosed ... life. Not infrequently death supervenes be- ...lequate studies can be carried out. In the acute ...here is usually a sudden onset with severe pain in ...est or abdomen. The pain may radiate rapidly ...ection progresses. Collapse, shock, and death ...ccur immediately or be delayed for weeks or ... In these latter cases roentgen examination ...e of considerable value. The most significant ... is widening of the supracardiac area. The ...e may be to either or both sides. A sudden in- ...in width of the aortic shadow roentgenologi- ...diagnostic of dissecting aneurysm. Extravasa- ...blood into the pericardial sac or pleu al cavities ...cur, and the roentgen signs of pericardial and ...effusion may then be elicited. Cardiac hyper- ...is frequently present.

...ve case reports are included.

L. W. PAUL, M.D.

...ns of the Diaphragm, with Special Reference ...tration and a Report of Three Cases. Richard ...er and James C. Cook. Am. J. Roentgenol. ...-614, December 1944.

...eries of 412,149 chest roentgenograms made at ...ed Forces Induction Station, 38 examples of ...gmatic lesions were found. Of these, only ...re considered to be true diaphragmatic hernias. ...aining 35 cases were instances of eventration ...aphragm, 30 occurring on the left side and 5 on ...t. Eventration is generally considered to be ...ital condition, since it has been found in the ... Pathologically, degeneration of the phrenic ...condary to trauma, tumor growth, and cervical ...osis have been reported, and it may be that ...ses represent a birth injury to the phrenic ...her than a true congenital anomaly.

...agnostic roentgen signs of eventration are a ...tion, a regular arched contour, and possible ... excursion due to the defective musculature. ...erential diagnosis between eventration and ...ay be difficult and at times impossible.

...of the cases of right-side eventration are re- ...iefly. In two of them gas-filled loops of in- ...ere visible in the lower right thoracic cavity ...m studies revealed parts of the stomach, ...small intestine within the space between the ...and liver.

...h most cases of eventration are asympto- ... abnormality becomes of clinical significance ...esults in gross displacement of abdominal

L. W. PAUL, M.D.

THE DIGESTIVE SYSTEM

Non-Malignant Duodeno-Colonic Fistula. James B. McClinton. Canad. M. A. J. **51:** 434–436, November 1944.

A case of benign duodeno-colonic fistula, diagnosed preoperatively with the aid of a barium enema, is presented. Only four other cases of this condition have been recorded in the literature since 1885 (see McPeak: Radiology **34:** 343, 1940). All cases followed rupture of a duodenal ulcer without operation.

Roentgenologic Diagnosis of Gallstone Ileus, Specially as Regards the Demonstration of Obstructing Radiotransparent Concrements. Flemming Nørgaard. Acta radiol. **23:** 622–628, Dec. 15, 1942. (In English.)

The author reports 3 cases of gallstone ileus in which the diagnosis was established by roentgen examination prior to operation. Although the obstructing concrements in two of these cases were radiotransparent, the diagnosis was made without the use of contrast substances, from a filling defect in the pathologically gas-filled portion of the intestinal lumen. In all cases the obstructing gallstones were shown by the roentgenograms (and found at operation) to lie in the distal ileum.

MAX SGALITZER, M.D.

Roentgen Diagnosis of Incipient Cancer of the Rectum. Albert Oppenheimer. Am. J. Roentgenol. **52:** 637–646, December 1944.

The usual barium enema examination has not been satisfactory for the detection of rectal cancer except in its advanced stages. The author has modified the enema examination so that better demonstration of rectal lesions can be obtained. A flexible urethral catheter is inserted into the rectum and a small quantity of opaque medium is injected under roentgenoscopic control. In most cases 20 to 60 c.c. are sufficient for adequate visualization of the rectum and sigmoid. In addition to spot films, roentgenograms may be made in various positions. After study of the rectum and sigmoid is completed, the rest of the colon is filled in the usual manner.

By this method small lesions in the rectum can be identified. Early cancer of the rectum shows one constant sign, a small ulcer with rigid walls. Filling defects and shelf formation are rarely present. With massive filling the lesion is easily obscured. As the tumor grows, constriction becomes evident, and there may be nodular prominences encroaching upon the lumen.

Carcinomatous polyps, when single, are difficult to see roentgenologically. They produce rounded filling defects as elsewhere in the gastro-intestinal tract. Polyps should be searched for since they may cause no symptoms and a majority will contain foci of carcinoma histologically.

L. W. PAUL, M.D.

Contours of the Right Lobe of the Liver in Ascites. Hans Hellmer. Acta radiol. **23:** 533–540, Dec. 15, 1942. (In German.)

The author shows that in patients suffering from ascites, the lateral contours and parts of the inferior contours of the right lobe of the liver can be demonstrated in roentgenograms of the right upper quadrant without any application of contrast medium to the hepatic parenchyma. By comparison of the different widths

of the interspace between liver and thoracic cage in serial roentgenograms, conclusions are possible regarding the progress of the disease.

MAX SGALITZER, M.D.

Acute Pancreatitis with Special Reference to X-Ray Diagnosis. David Metheny, Edward W. Roberts, and Allan Stranahan. Surg., Gynec. & Obst. 79: 504–508, November 1944.

The authors report 10 cases of acute pancreatic edema and 17 cases of acute pancreatic necrosis proved at operation or autopsy, together with 5 cases in which the diagnosis of pancreatitis was made on clinical and laboratory findings.

The roentgen findings suggestive of acute pancreatitis are: (1) tender tumefaction of the pancreas found on fluoroscopy, (2) changes in the stomach and duodenum, (3) evidence of localized or generalized ileus. The duodenum shows ileus and loss of tone and on fluoroscopy barium can be pushed into it but fails to move on by peristalsis. The duodenal loop is enlarged. Occasionally enough gas is present in the stomach so that elevation and flattening of the greater curvature can be shown. Increased density of the pancreatic area and an increased space between the greater curvature and transverse colon may also be demonstrable. More frequently a fair-sized "blob of gas" is present in the cardia and a smaller one in the duodenal bulb. Localized ileus, especially of the transverse colon or upper loops of jejunum, occurs. These changes are often evident on a plain scout film of the abdomen in the supine position. The roentgen findings persist as long as the disease lasts.

All the authors' cases had an acute onset with nausea, vomiting, and epigastric pain, but tenderness was often minimal. The temperature and blood pressure were normal and the pulse slow in early cases. Albuminuria was invariably present. The patients with pancreatic necrosis were sicker than those with pancreatic edema and showed a higher total leukocyte count and a higher percentage of polymorphonuclears.

Of the 17 patients with pancreatic necrosis, 10 showed cyanosis, 9 distention, 4 rigidity and tenderness, 4 glycosuria, and 2 jaundice with associated cholelithiasis. The blood amylase remained elevated as long as the disease lasted in the cases of pancreatic edema but returned to normal within two days in the cases of necrosis.

Seventeen patients were treated surgically by various procedures, including cholecystostomy, cholecystectomy, choledochostomy, and gastroenterostomy. Of the 9 patients with pancreatic edema who were operated upon, all survived. Three of the 8 with pancreatic necrosis who were treated surgically survived. The authors believe that survival is more dependent upon the benignity of the disease than upon the type of surgical procedure. For the acute phase of the disease they consider non-operative measures preferable.

One patient with a typical clinical picture of acute pancreatic necrosis and suggestive x-ray findings was given supportive therapy and a small therapeutic roentgen dose. She improved rapidly, and the roentgen findings disappeared. Fourteen days later she was operated on. Stones were found in the gallbladder and ducts and the pancreas was slightly indurated.

Roentgenograms from 9 cases are reproduced.

FRANK P. BROOKS, M.D.

Pancreatic Collections (Pseudocysts) F... Pancreatitis and Pancreatic Necrosis: Re... Analysis of Ten Cases. Roland D. Pinkh... Gynec. & Obst. 80: 225–235, March 1945.

The author reviews the literature and ... the formation of pancreatic collections (p... following pancreatitis and pancreatic ne... points out that the pseudocysts may be lo... the substance of the pancreas as the result of ... tive changes affecting the interstitial ... parenchyma of the gland. The three comm... listed as (1) between the stomach and the ... colon, under the gastrocolic ligament; (2) be... stomach and the liver; (3) between the la... transverse mesocolon.

The relation of acute and chronic pancrea... production of pancreatic cysts and supp... well established. Following the first episo... creatitis, the pancreas appears to be more ... recurrent insults. Since there seems to be ... way to differentiate, at laparotomy or necrop... hematogenic collections, pseudocysts, and ... suppurations, the classification and diagnos... accumulations are subject to wide individual ... tion. It appears logical to disregard the te... or "pseudo" cysts, and designate these as ... cysts or collections resulting from trauma (... indirect), duct obstruction (calculi, tumor, ... tion), acute and chronic pancreatitis (... chemical), and pancreatic necrosis (infectious ... and vascular). The term "retention" cysts ... used to designate ductal dilatation arising sec... partial or complete occlusion of the pancrea... whereas "true" cysts should be limited to the ... proliferative, hydatid, dermoid, or congenital c...

The author discusses the significance of ... serum amylase; also when the cyst cont... a high concentration of amylase or any tryp... agnosis of pancreatic origin is assured.

Ten cases are reported: 6 were collections ... to pancreatic necrosis; 2 subsequent to ... pancreatitis; 2 to chronic pancreatitis.

The diagnosis of pancreatic collections ... from a clinical point of view but little ... nature is to be found until the palpating ... mass in the epigastrium; only then can we ... Serum amylase determination is of great ... roentgenographic studies were found of ... routine examinations showed a mass in the ... region and gastric pneumograms [see paper ... on page 128 of this issue of RADIOLOGY] ... in the localization. However, the diagnos... made preoperatively with certainty.

THE PERITONEUM

Diffusion and Localization of Experimental ... of the Peritoneum. Bernhard Steinberg and ... Martin. Surg., Gynec. & Obst. 79: 457–4... ber 1944.

A previous contribution by Steinberg (... 116: 572, 1941) showed the diagnostic and ... value of study of the exudate drawn from the ... toneal cavity. The present paper endeavors ... the prevailing view that peritoneal infectio... from a focus against a defense barrier ... body and that a diffuse infection of the p... ity is inimical to recovery. The auth...

...he infection is at once disseminated fairly uni-... in order that the body defenses can better deal ...

...erimental infections of the peritoneal cavity were ...d in dogs by various methods—ligation of the ...lix and administration of castor oil; injection of ... cultures of bacteria into the lumen of the ap-...; injection of infectious material into the pelvic ... Spread of the infection was followed by in-... iodized oil along with the infectious material ... lowing its dissemination by x-ray studies. Two ...ere killed at different intervals and the peritoneal ...s investigated.

...as found that diffusion throughout the peritoneal ... after appendiceal perforation was rapid (twenty ...s to two hours). The spread was surprisingly ...l, and the exudate showed a uniform bacterial ...hroughout the peritoneal cavity except on the ... of the appendix and in the right subdiaphrag-...rea, where the count was much higher. Local-...ccumulations (abscesses) occurred in animals ... signs of recovery.

... advantages of diffusion of the bacteria over a ...eritoneal surface are threefold: (1) The micro-...ms are distributed in smaller numbers, so that ... a more efficient and speedier phagocytosis. ...greater number of phagocytic leukocytes are ... migrate into the peritoneal cavity and probably ...n accelerated tempo. (3) Passage of a large ... of bacteria through the lymphatic and capillary ...s made possible.

...itions which may bring on a fatal outcome are: ... presence in the peritoneal cavity of environ-... conditions which delay bacterial removal or ... the rapidity of bacterial multiplication; ...xtensive initial or a continuous outpouring of ...

...bservation that bacteria and leukocytes ac-...e in the right subdiaphragmatic region in ... numbers than elsewhere in the peritoneal ... interesting from the point of view of formation ...phrenic abscess. Changes in posture did not ...to alter appreciably such tendencies. The ...action of the diaphragm and the anatomic ...way formed by the right lateral gutter may ... for the greater accumulation of bacteria and ...es in that region. Massive bacterial invasion ...ea with a resultant vascular stasis and closure ...mation of capillary and lymphatic vessels by ... microorganisms are removed probably com-...e process of subphrenic abscess formation. ... light of their findings the authors question ...om of efforts to delimit and circumscribe the ...s process. They suggest the terms, "regress-... progressing" peritonitis to indicate, respec-...avorable and unfavorable progress, and would ...he current designation of "diffuse" or "spread-...tonitis.

J. L. BOYER, M.D.

THE SPLEEN

...y Calcified Cyst of the Spleen. Report of a ... W. Neidhardt. J. Kansas M. Soc. 45: ...November 1944.

...ar-old male was struck about the region of the ...chest when the ditch in which he was working ... Pain on deep breathing followed, with considerable tenderness in the left upper quadrant and lower chest and limitation of respiratory movements. Roentgenograms revealed no fractures, but a nearly circular, sharply outlined mass was seen in the left upper quadrant. The left side of the diaphragm was elevated, the apex of the heart was displaced considerably to the left, and the transverse colon and left kidney were displaced downward on the left side. Two weeks later a laparotomy was performed and the mass was identified as a calcified cyst in the splenic region. At its upper pole numerous fairly recent adhesions were present. The cyst, which was ruptured in its removal, contained approximately 1,000 c.c. of thick chocolate-colored fluid, with a large number of minute shimmering crystals. Since the spleen was not found, it was assumed to be incorporated in the cyst. The pathologic diagnosis was solitary calcifying cyst of the spleen, acute and chronic splenitis, and perisplenitis. The patient made an uneventful recovery following the splenectomy.

THE SKELETAL SYSTEM

Severe Osteitis Fibrosa Cystica with Parathyroid Tumor. Report of a Case of Fifteen Years' Duration. Donald E. Coburn. Am. J. Surg. *66:* 252–258, November 1944.

A severe case of generalized osteitis fibrosa cystica due to a parathyroid adenoma located in the superior mediastinum is reported.

A 60-year-old woman complained of severe pain in the right hip radiating down the posterior aspect of the right thigh, of six months' duration. During this time she had become progressively shorter, had worn a brace to support her back, and required the aid of crutches. In the previous 16 years she had suffered no less than four fractures and had undergone one operation for kidney stones.

The patient's features were coarse and puffy, the skin was dry and subicteric, and the hair dry and brittle. The thyroid was not enlarged, but there was a questionable fullness opposite the lower pole on the right. The entire left side of the chest was compressed and flattened toward the right, producing a modified pigeon-breast deformity. The right side of the chest flared, rib spaces were prominent, and respiratory excursion on this side was nearly normal. The spine was more or less rigid, with a prominent dorsal kyphosis and an accompanying right roterolateral dorsal scoliosis. Motion in the right hip was painful and restricted in all directions. Reflexes were sluggish; cutaneous sensation was normal.

X-ray examination of the skull showed the calvarium to be thickened, while the bones of the vault had a fine, mottled, granular appearance. The maxillary and sphenoidal sinuses appeared enlarged. Roentgenograms of the upper extremities showed areas of absorption with cyst formation in the upper ends of both humeri, the left ulna, the right radius, the right os magnum, the third left metacarpal, and in the proximal phalanx of the right first and the left second fingers. The site of a previous fracture of the right humerus could be easily seen. In the right femur a mass of thin-walled cystic cavities completely replaced the normal bone structure of the upper two-thirds. The overlying cortex was extremely thin and somewhat expanded. Cysts were also present in the right tibia, the left tibia, both patellas, and in the first left meta-

tarsal. A film of the abdomen showed numerous areas of increased density in both kidney regions, consistent with the diagnosis of nephrocalcinosis. Films of the pelvis revealed extensive involvement of both innominate bones with compression and distortion of the entire left half of the pelvis upward and inward to create a typical oblique deformity. There were large cystic areas of bone destruction in the region of the right acetabulum and right ilium. Multiple areas of cystic formation were present in the ribs, and there was almost complete loss of substance of the third, fourth, fifth, and sixth dorsal vertebrae.

The patient's history and the x-ray findings suggested a diagnosis of osteitis fibrosa cystica due to parathyroid adenoma. An elevated blood calcium with a decreased blood phosphorus and increased blood phosphatase confirmed the diagnosis.

At operation, a tumor measuring approximately 3.5 × 2 cm. was found in the superior mediastinum. This was removed without difficulty. Convalescence was marked by a fracture of the right femur. Films taken about ten weeks following operation, however, showed the fractured femur to be in good alignment, with some callus formation. There was also evidence of beginning recalcification throughout the entire skeletal system. About four months later continued recalcification was demonstrable; many of the cystic areas in the extremities had begun to fill in and the surrounding cortex was appreciably increased. Films of the abdomen at this time showed the areas of nephrocalcinosis in both kidney regions to be essentially the same as on previous examinations. For this reason the prognosis must be guarded, as it has been shown that such deposits may ultimately result in death through the continued destruction of kidney tissue long after the primary tumor has been removed. Numerous roentgenograms are reproduced.

Importance of Degeneration of the Cervical Disks for the Narrowing of the Intervertebral Foramina. Fred Haglund. Acta radiol. **23:** 568–580, Dec. 15, 1942.

An account is given of the result of an anatomical examination of degeneration and protrusion of the cervical disks. Degeneration of the disks is often followed by protrusion, which may occur posteriorly, in the direction of the spinal canal; postero-laterally, in the direction of the entrance of the intervertebral foramina; laterally, in the direction of the external part of the intervertebral foramina and vertebral artery. The most important observation, with regard to the occurrence of brachialgia, concerns the conditions following disk protrusion in a postero-lateral direction. The author has discovered and describes cases of narrowing of the intervertebral foramina caused by disk protrusion with ensuing pressure on the spinal nerves.

MAX SGALITZER, M.D.

Dilatation of the Vertebral Canal Associated with Congenital Anomalies of the Spinal Cord. A. Earl Walker. Am. J. Roentgenol. **52:** 571–582, December 1944.

Four cases are presented in detail to illustrate the fact that dilatation of the spinal canal may occur as the result of congenital anomalies of the cord structures. In 3 of the cases the enlargement of the canal was associated with myelodysplasia. In the fourth there was a vascular anomaly of the cord. Except in this last case, there was no evidence of pressure on the spinal cord [illegible] the enlargement of the canal presumably occurred [illegible] in the course of development, probably at the time [illegible] ossification centers were laid down. In one of the[illegible] the enlargement occurred in the lumbosacral [illegible] and was associated with myelodysplasia and a [illegible] lipoma infiltrating the roots of the cauda equina [illegible] the second case, also in the lumbar region, wide[illegible] the interpedicular spaces was associated with [illegible] myelia, the cord being split into two component[illegible] other anomalies. In the third case a similar [illegible] of the cord was found in the cervico-dorsal region [illegible] associated with widening of the interpedicular spa[illegible] this level.

Although neoplastic conditions cause most [illegible] of roentgenographically demonstrable enlarge[illegible] the spinal canal, these cases emphasize that con[illegible] abnormalities of the spinal cord must also b[illegible] sidered as etiologic factors. L. W. PAUL, [illegible]

Role of the Nucleus Pulposus in the Pathoge[illegible] So-Called Recoil Injuries of the Spinal Cord. [illegible] Cramer and Francis J. McGowan. Surg., Gyn[illegible] Obst. **79:** 516–521, November 1944.

In the condition known as "recoil" injury, the [illegible] cord may be severely damaged without demon[illegible] or commensurate injury to the spinal colu[illegible] usual causes being diving or automobile acc[illegible] Forceful anterior flexion, the head being "whip[illegible] forward, is the mechanical cause. The path[illegible] of this injury has been believed to be sudden [illegible] dislocation of the vertebral body, which then re[illegible] reflex contraction of the antagonist muscle[illegible] authors, however, question this explanatio[illegible] theory being that the injury to the cord is d[illegible] violent protrusion of the intervertebral d[illegible] rupture of the nucleus pulposus when su[illegible] sudden intense compressive force.

The report of a case of injury due to [illegible] shallow water is presented. A traumat[illegible] a quadriplegia, developed, and death o[illegible] hours after the accident. A lateral film o[illegible] spine showed a slight compression fracture o[illegible] terior portion of the fifth cervical vertebra as [illegible] slight narrowing of the posterior portion of th[illegible] vertebral space, without any evidence of dislo[illegible] the vertebral body. Autopsy confirmed a [illegible] fracture of the body and arch of the fifth [illegible] vertebra plus acute traumatic prolapse of t[illegible] vertebral disk between the fourth and fifth [illegible] vertebrae. Opposite the fifth intervertebral [illegible] spinal cord was practically severed except fo[illegible] terior columns and the posterior portion of the [illegible] case illustrates laceration of the spinal cord [illegible] severe traumatic prolapse of the intervert[illegible] the projectile force of the compressed nucleu[illegible]

The authors found, in reviewing the liter[illegible] there were descriptions and photographs of [illegible] similar cases, showing herniations of the nu[illegible] posus; yet the cord injury was usually a[illegible] to dislocation with recoil. This momentary [illegible] dislocation with immediate spontaneous r[illegible] is held to be improbable on anatomic grou[illegible] authors believe that the autopsy findings [illegible] cases, as well as their own, point to traumati[illegible] the cord by the intervertebral disk as a resul[illegible] pression of the nucleus pulposus or its herniati[illegible]

ROBERT E. BOOTE.

nful Shoulder Due to Lesions of the Cervical . Bernard N. E. Cohn. Am. J. Surg. 66: 269– November 1944.

s paper deals with lesions of the cervical spine may cause a painful shoulder with radiation of nto the arm. When a patient presents himself e relief of pain in the shoulder region and arm, a variety of conditions must be considered, includ- pertrophic arthritis of the cervical spine, herni- intervertebral disk, cervical rib, the various ides, and local lesions of the shoulder region, as is, periarthritis, bursitis, and tears of the supra- us tendon. Diagnosis can be made only after and detailed physical and roentgenographic ation. The cervical spine should be examined ly in all cases of painful shoulder in which there ufficient signs to verify the diagnosis of a local or neuritis and in those cases of presumptive er pain which do not respond to therapy within a ble period of time.

cases (hypertrophic arthritis of the cervical metastatic carcinoma of the cervical spine; losis of cervical spine; herniated cervical in- ebral disk) are presented to show the difficulties d in arriving at a correct diagnosis.

ogy of Phosphorus Sclerosis. Olov Fr. Holm. diol. 23: 549–561, Dec. 15, 1942. (In German.)

the enactment (1929) of an insurance law for ional diseases in Sweden, one case of phosphorus ng has occurred in which payment had to be Phosphorus sclerosis originates during processes cation. In severe cases hard zones are produced ay last during the life of the patient; in milder e sclerotic zones may disappear completely.

stages of chronic phosphorus poisoning are d: (1) the stage of calcium deposition, repre- by broad and dense epiphyseal lines (the at this stage are reversible, and if the exposure ntinued, the lines may entirely disappear); stage of persistence of epiphyseal lines, in which on and absorption counterbalance each other; stage of bony atrophy, osseous fragility, im- t of fracture healing, and tendency to bone (especially in the jaw). Bone necrosis itself is nfection in atrophic bone damaged by the effect phorus.

istories of 4 patients, 3 of whom had worked in actories, are recorded, and roentgenograms are ed.

MAX SGALITZER, M.D.

c Bone Necrosis of the Os Capitatum (Os). Gunnar Jönsson. Acta radiol. 23: 562– 15, 1942. (In English.)

thor describes a case of aseptic necrosis in the tum in a 22-year-old female with no history of The picture resembled, both clinically and ologically, the changes characteristic of ma- he os lunatum (Kienböck's disease).

MAX SGALITZER, M.D.

Fractures, a Series of Fifty-Eight. Walter and James H. Wooten, Jr. Mil. Surgeon 359, November 1944.

ight cases of fracture of the metatarsus in 55 are reported. Fifty-three men successfully d the course of training in a replacement center with physical activities which included marches up to 25 miles. Two patients had subsequent march fractures, the first, one, and the second, two.

Roentgenograms of the foot taken immediately after onset of symptoms may not reveal the fracture line. Treatment is begun at once in all patients with signs of march fracture, and the x-ray examination is repeated in one week in those with initial negative roentgen findings. At this time evidence of callus formation will reveal the site of the fracture even though the fracture line is still not discernible. This follow-up roentgenogram proved to be essential.

The authors advise that patients with march fractures be treated as outpatients, with the Army shoe as a splint whenever possible. Prophylactic measures—gradual increase in the length of marches and in the weight of equipment and marching on soft rather than hard ground—were found to reduce the incidence of these fractures.

GYNECOLOGY AND OBSTETRICS

Roentgenologic Diagnosis of Placenta Previa. G. Sohrne. Acta radiol. 23: 541–548, Dec. 15, 1942. (In English.)

A method is described by the author by means of which the presence or absence of placenta praevia may be demonstrated. Air is introduced as a contrast medium into the urinary bladder and the rectum. The catheter is then withdrawn. Frontal roentgenograms are supplemented by views taken in oblique projections in both directions, and, when necessary, in the lateral position.

In some cases, the placenta is directly visualized. In most cases, conclusions are based on the size and configuration of the interspace between the upper pole of the bladder and the fetal head.

MAX SGALITZER, M.D.

THE GENITO-URINARY TRACT

Perirenal Insufflation. Fedor L. Senger and John J. Bottone. Am. J. Surg. 66: 213–219, November 1944.

In cases in which overlying malpositioned organs, pocketed intestinal gas and contents, or perirenal adhesions and perinephritis obscure the kidney borders, the authors have found perirenal air injections of value. By surrounding the kidney with an envelope of air, they have obtained useful added information in unusual cases of ptosis, rotations or failure of rotations, malformation, and agenesis or atrophy of the kidney. The procedure also supplies knowledge concerning the local spread and operability of renal tumors. Complications are infrequent and of minor degree if ordinary care is taken. A series of 175 cases of perirenal air injection without serious mishap is presented. The technic is described. Roentgenograms are reproduced.

Reflex Anuria Following Retrograde and Excretory Investigation. Benjamin Levant and Krikor Yardumian. Urol. & Cutan. Rev. 48: 554–556, November 1944.

So-called reflex anuria may be due to a definite pathological factor. In other instances, no obvious lesion is present, and it is with such cases, particularly follow-

gnancy of a given tumor can apparently be estid by the extent of its departure from that pattern. eatment is prophylactic, definitive, and palliative. lcation of adenomas is a relatively simple procand is highly effective as a prophylactic measure. a report of carcinoma is unexpectedly returned, ration to remove the involved lobe and suspected issue is justified. The operation should be extenenough to remove all involved structures and yet rve at least one recurrent nerve, one parathyroid , and both carotid arteries. Tumor invading the ea should be excised flush with the tracheal wall. astinal extension of malignant tissue often proves the unsurmountable obstacle to complete removal tumor but several procedures have been devised complish this result.

ntgen therapy can be used alone for palliation or ined with surgery in an attempt to eradicate the ie. Even in advanced cases, a biopsy should be rmed before irradiation is carried out. This offers dvantage of establishing the diagnosis and preig irradiation of a pure papillary tumor, which break down and ulcerate because of its extreme ensitivity.

principal value of x-ray therapy lies in its adtration postoperatively, for the elimination of cans tissue not detected or not removable at opera- Such tissue is frequently located in the mediastiand for this reason the mediastinal space should luded in the area treated. Three thousand roentelivered to the tumor bed are considered to be the limit of effective dosage. The best results can be ed to occur in tumors shown to be predominantly ary. Except in these papillary tumors and in a number of malignant adenomas, irradiation seems of little value. No case of anaplastic large- or cell carcinoma, or carcinosarcoma has shown a ble response to treatment either by surgery or tion.

results of treatment of locally recurrent tumors netastatic deposits are influenced even more ly by the pathologic pattern of the growth than e results of treatment of primary neoplasms. If tastases are from a well differentiated tumor preantly papilliferous, their response to irradiation lly good. Locally recurrent nodules, especially if mary growth was a malignant adenoma, respond to irradiation and should be removed.

J. E. WHITELEATHER, M.D.

vial Sarcoma. Cushman D. Haagensen and Purdy Stout. Ann. Surg. 120: 826–842, De- 1944.

nsiderable number of cases have been reported as l sarcomas which in reality were xanthomatous ell tumors, tumor-like hyperplasias of the synosues, or other benign lesions curable by simple . The apparent cure rate for synovial sarcoma s been made to appear higher than it actually is. btain confirmation of the mesothelial nature of plasm, tissue culture studies were carried out in 3 This work is reported by Murray, Stout, and I (Ann. Surg. 120: 843, 1944). The three from which cultures were obtained had striking ic characteristics. They were composed of an able admixture of mesothelial cells, which often ts or tubes and secreted a mucicarminophilic substance, with strands of active, hyperchromatic fibrosarcoma-like cells associated with reticulin fibers. The relative amounts of these two cell forms varied enormously, but both were always present.

With these characteristic histologic features in mind, cases reported as synovioma, synovial sarcoma, or designated by some related term, were re-examined and those which did not fulfill the criteria were rejected. This screening yielded 95 cases, to which the authors add 9 previously unreported examples.

The condition occurs preponderantly in males, the proportion being 3:2. Although the tumor may develop at any age, it is more frequent in early adult life. The mean age of the 103 patients whose age is known was 32 years. Nearly one-half of the tumors developed in the region of the knee joint.

Of the 104 patients with synovial sarcoma, only 3 are known to be free from evidence of persistence or metastasis more than five years after treatment. The therapy employed has been of four general types: (1) radiation alone or in combination with surgery; (2) local excision, often repeated several times; (3) excision, or exploratory operation with an attempt at excision, followed immediately, or within a short time, by amputation; and (4) biopsy followed shortly by amputation.

Radiation appears to have been singularly futile in this disease. It has often been employed, but five-year cure has not been obtained in a single case in which radiation was the chief reliance. One patient was well six years after treatment, but in this instance irradiation was followed by amputation. The authors were unable to find any clear evidence that radiation is even of palliative value.

Local excision was undertaken in 84 of the 104 cases tabulated. As with other forms of fully malignant sarcoma, any sort of local excision almost always fails to cure. Secondary amputation for recurrence following local excision was performed in 26 of this group of conservatively treated patients, but none was cured.

Excision, or exploratory dissection with an attempt at excision, followed immediately or within a short time by amputation, was carried out in 7 patients. Only one of these patients appears to have been cured.

In 4 cases, a simple biopsy was done, followed shortly by primary amputation when the malignant nature of the lesion became clear from histologic study. Although 3 of these patients subsequently had pulmonary metastases, the fourth has been well for eight years. This is the longest survival on record following any form of treatment for synovial sarcoma. This case, one of the authors', is reported in detail.

The authors believe that the most radical surgical attack—carefully limited biopsy and a high immediate amputation—is the rational therapy for synovial sarcoma. A biopsy must be done because it is impossible to diagnose synovial sarcoma, as well as a variety of other deep soft-part tumors, from the clinical picture alone. An incisional biopsy is essential, for the diagnosis of the tumor rests to a considerable extent upon the histologic architecture. The dissection should be as limited as possible. The diagnosis having been proved histologically, amputation should be performed promptly and at high enough level to avoid local persistence of the disease. Since regional lymph node dissection is not a hazardous operation, it should be seriously considered as a separate and final stage in the treatment of synovial sarcoma.

The Place of Surgery in Fibroids of the Uterus. Channing W. Barrett. Am. J. Surg. 66: 148–156, November 1944.

This is a more or less general discussion of surgical and radiation therapy of fibroids of the uterus, written from the point of view of the surgeon. The author believes that radiation should be used only in small tumors occurring at the menopause, presenting no complications and no symptoms beyond slight or moderate bleeding.

Some Effects of Testosterone, Testosterone Propionate, Methyl Testosterone, Stilbestrol, and X-Ray Therapy in a Patient with Cushing's Syndrome. Martin L. Deakins, Harry B. Friedgood, and Joseph W. Ferrebee. J. Clin. Endocrinol. 4: 376–384, August 1944.

The metabolic and clinical effects of testosterone propionate, stilbestrol, methyl testosterone, and testosterone were observed under controlled conditions in a fifteen-year-old girl with Cushing's syndrome. Injections of testosterone propionate, 25 mg. per day, caused a diminution in nitrogen excretion and a disappearance of creatinuria Stilbestrol, 2 to 10 mg. per day, intramuscularly, did not affect nitrogen excretion but perhaps induced a moderate increase in creatine excretion. Methyl testosterone, 40 mg. per day, orally, caused a striking decrease in nitrogen excretion and a tremendous increase in creatine excretion. Creatinine excretion remained unaltered. Testosterone, 40 mg. per day, orally, did not produce unequivocal changes in excretion of nitrogen, creatine, or creatinine.

Irregular increases in 17-ketosteroid excretion, with levels as high as 26 mg. per day, occurred during administration of testosterone propionate. During recovery from the effects of this hormone and also in the period of stilbestrol administration, the 17-ketosteroid excretion averaged about 12 mg. per day. Methyl testosterone caused an initial 3-day increase in 17-ketosteroid from 15 up to 25 mg., followed by a depression to levels of about 5 mg. Free testosterone caused a precipitous and marked rise in 17-ketosteroid excretion. Thirty-eight to 48 mg. of ketosteroid was excreted on the 40-mg. dose and over 100 mg. on the 150-mg. dose. The pattern of biochemical activity of these hormones suggests marked differences in their metabolism.

The androgens induced distressing accentuation of acne, hirsutism, and hypertrophy of the clitoris. Stilbestrol improved these conditions, but the benefit was not striking and was associated with certain untoward reactions and a transient hyperglycemia.

Three series of roentgen irradiation were given, each consisting of eight daily exposures of the hypophyseal region through two portals (right and left temporal). A total of 6,480 r was administered in a period of ten months. This therapy appeared to improve the subjective and objective manifestations of the disease.

NON-NEOPLASTIC DISEASES

Effect of Grenz Rays on Leprous Infiltrations: Report of an Attempt to Influence Leprous Infiltrations by Roentgen Rays of Long Wavelength. Felix Sagher. Arch. Dermat. & Syph. 50: 311–314, November 1944.

There is no specific therapy for leprosy. In fact, no therapeutic measure now known can even influence a localized lesion.

Radium and x-ray have been tried on leprous and, while there have been some favorable res vere damage has occurred to the surrounding underlying tissues. As grenz rays do not pe deeply and their effect on underlying tissue therefore be negligible, the author decided to try effect in two patients with relatively superficial which had failed to respond to the usual me treatment. Each of the patients was treated different areas, the lesions being of varying thickness. The treatment factors were 6 to equivalent of half-value layers of 0.021 to 0 aluminum, 10 ma., 10 cm. focal skin distance. tal dosages were from 600 to 8,000 r to an area, four to six weeks. On one area a single dose was given at one time. The results have been over periods of six months to two years months.

If more than 2,000 r was given to an area, would disappear in an interval of between fou and a year. There was some atrophy of the this was not greater than in a similar area whe had disappeared spontaneously. There was atrophy of the skin in the area that was trea 5,000 r at one time. Even though the lesions peared, Hansen bacilli were constantly found at each test.

In both patients new lesions developed unde vation. "It was a particularly striking feat newly developing infiltrations in the surround halted at the border of the treated areas."

JOSEPH T. DANZER,

Use of Radon to Prevent Otitis Media Due to plasia of Lymphoid Tissue and Barotrauma Otitis). Edmund P. Fowler, Jr. Arch. Ot. 40: 402–405, November 1944.

In England, American soldiers have bee more prone to have hyperplasia of pharyngeal tissue, secondary eustachian salpingitis, and otitis media than in the United States. In the and throat section of one general hospital, of ground personnel and 22 per cent of flying had a history of recent otitis when examined all of these patients had sufficient excess lym sue around the eustachian tubes to account From December 1942 to March 1944, 220 pati treated with radon for this condition. Cap of platinum 0.65 mm. thick, measuring 3.5 mm., attached to a semimalleable 18 gauge cm. in length, were used. Each capsule con millicuries of radon. Two radon capsules (to mc. the first day) are passed along the floor and then separated by placing a small piece tubing over the insertion wires outside the They are left in place twenty-six minutes th giving a dosage of 66 milligram hours. The sules as a rule lie very near any exuberant tissue on the medial side of the torus tuba convenience they are considered as a single so timating dosage. Since the capsules are sepa ever, the total effect of 66 milligram hours reach any area in the nasopharynx. On treatments were given at intervals of six we four to six treatments had been administered the interval between treatments was reduced weeks, with no untoward results. [The auth in a footnote, that since the submission of th

found 100 milligram hours with filtration of n. of platinum at four-week intervals much more :tory than the use of 66 milligram hours at three- tervals. With this method, often two treatments een sufficient, although three were usually neces- id four were given to maintain the improve-

en with subacute blockage of the eustachian ten get along perfectly well on the ground or even ltitudes, but when they fly high or are subjected d changes of altitude, the eustachian tubes close they cannot be opened. This otitic barotrauma es conditions varying from a mild catarrh of the ear to acute, severe otitis with or without rup- id the involvement may even go on to an acute t process. None of these conditions develops if taehian tubes are functioning properly. Most nalfunction is due to swollen tissue within them. ition to lymphoid tissue, there are frequently glands, edematous mucosa or submucosa, and e secretion blocking the tubes. The cold air of itudes often causes hypersecretion in the nose, secretion bathes the tubal orifices and blocks or them. Apparently radiation reduces the ac- f the glands, shrinks the edematous tissue, and pecific effect on hyperplastic lymphoid tissue. bable that the radiation also has a beneficial ef- he infection present.

ican soldiers after a few months in England ve so much excess lymphoid tissue that as soon outh is opened this tissue can be seen bulging e posterior pharyngeal wall or behind the pos- nsillar pillars in heavy bands. It is particu- ominent following virus bronchopneumonia. ays in the dosage given do not sufficiently reduce sses of hyperplastic lymphoid tissue in the mid- 24 patients in this series underwent adenoid-

airmen with recurrent otitis media treated with 00 mg. hr. or more) on whom the follow-up in- on is complete, 23 are flying again and 28 are titis. Seventy-five per cent of the ground per- ho had sufficient treatment were free of otitis r at least four months. Some of this group would have become well without treatment ntually some of them will have recurrences. or believes that treatment of the lymphoid tis- t the eustachian tube with radon or radium is more efficacious and the effects more perma- n those of catheterization, politzerization or ge. It requires, however, the continual guid- qualified radiologist.

RADIATION EFFECTS

l and Roentgen Aspects of Irradiation Stric- e Rectum and Sigmoid: Its Course and Treat- . C. McIntosh and J. E. Hutton. Am. J. ol. 52: 647–662, December 1944.

he basis of a series of 44 cases of post-irradia- y of the bowel, the authors discuss the types which may occur and their medical manage-

mary damage in cases of gross bowel injury ic irradiation appears to be to the smaller dal vessels supplying the bowel, with throm- lusion resulting in infarction and mucosal The principal clinical complaint is diarrhea, which may occur as early as the third week after the beginning of treatment or not until some months later. The late development of symptoms may suggest an extension of the original lesion to involve the bowel, but this is uncommon in the authors' experience. Diagnosis is made by a carefully taken history, roentgen studies, sigmoidoscopy, and biopsy whenever possible.

The condition is best treated conservatively. Bed rest and a bland diet are indicated during the acute stage. Antispasmodics are helpful. A 6-oz. retention enema of 1 per cent tannic acid helps to control bleeding. If signs and symptoms of obstruction supervene, surgical treatment may be necessary.

Severe and extensive post-irradiation damage of the bowel often undergoes healing with very little functional impairment, though marked anatomic defects may be present. Such an outcome is materially assisted by careful medical treatment. L. W. PAUL, M.D.

Dwarfism Associated with Microcephalic Idiocy and Renal Rickets. S. J. Glass. J. Clin. Endocrinol. 4: 47–53, February 1944.

The author records a case of bizarre dwarfism associated with microcephalic idiocy and renal rickets, in a girl who died at the age of thirteen, of an intercurrent infection. When the patient's mother became pregnant she was suffering from inactive pulmonary tuberculosis and active tuberculous osteomyelitis of the sacro-iliac joint with a draining sinus. Because of preceding amenorrhea of about nine years' duration she was unaware of the pregnancy until about the third month. She then requested a therapeutic abortion. This was attempted by roentgen irradiation of the pelvis, without success. The irradiation, however, was persistently carried on at weekly intervals from the third to the eighth month. The dosage of roentgen radiation sustained by the growing fetus is not known. The pregnancy was finally terminated in the eighth month by cesarean section. The infant weighed two and three-quarters pounds. Dwarfism and imbecility became apparent in infancy, but there was no roentgen evidence of rickets until six months before the patient's death, and no obvious rickets was ever observed clinically. At autopsy extreme nervous and somatic hypoplasia was seen. This is considered to have been the result of brain damage induced by the roentgen irradiation and renal rickets.

Injury of Bones by Roentgen Treatment of Cancer of the Uterine Cervix. Frithiof Truelsen. Acta radiol. 23: 581–591, Dec. 15, 1942. (In English.)

The author reports three cases of spontaneous fracture of the femoral neck following intensive x-ray treatment for cancer of the cervix. In one case a microscopic examination of the bone tissue was made. Destruction of the bone marrow was found with features resembling an osteitis fibrosa and with necrosis of the bone tissue. There was complete lack of osteoblasts and osteoclasts.

The author believes that the influence of the x-rays on osteoblasts and osteoclasts is probably the chief cause of osseous changes following irradiation. Vascular changes followed by nutritive disturbances may also play an important part.

Since osseous changes in the femur may complicate radiotherapy of uterine cancer, radiographic examination of the pelvis is indicated in all cases of hip pain and

RADIOLOG

A MONTHLY PUBLICATION DEVOTED TO CLINICAL RADIOLOGY AND ALLIED

PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

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RADIOLOGY is entered as second class matter at Syracuse, New York, and Easton, Penna., under the Act of August 24, 1912, and accepted November 24, 1934. RADIOLOGY is published by the Radiological Society of North America as its official Journal. Subscription rate $6.00 per annum. Canadian and foreign postage, $1.00 additional. Single copies, 75¢ each. All correspondence relative to business matters connected with the Radiological Society of North America and RADIOLOGY, or remittance for non-member subscriptions, should be made payable to the Radiological Society of North America and should be addressed to the SECRETARY-TREASURER, DONALD S. CHILDS, M.D., 607 MEDICAL ARTS BUILDING, SYRACUSE 2, NEW YORK. In requesting change of address, both the old and the new address should be given.

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MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

45 SEPTEMBER 1945 No. 3

adiation Necrosis of the Calvarium: Report of Five Cases[1]

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HIS STUDY represents a review of 2,046 cases of intracranial tumors which treated by roentgen rays, either with without surgical measures. In this s only 5 cases of aseptic necrosis of the arium were found, but since in most ınces no follow-up roentgenograms available, this figure should not be idered a true gauge of the incidence is condition.

nce a review of the literature has d to reveal any report of similar ıges in the calvarium after roentgen ment of intracranial tumor, a presenta- of the pertinent data seems justifiable.

ne fact that irradiation affects bone e has been well known for a number of s. Ewing (1, 2) discussed radiation tis at length and also pointed out that, rary to the general concept, bone is slightly more opaque than most soft e and only to soft rays. Calcium, ı has an atomic weight of 40, must ry closely compacted in hard bone to the latter much more opaque than le, skin, or tendon.

Regaud (3), in 1922, first called attention to the great susceptibility of the jaws to necrosis and concluded that bone is more prone to react to radiation than is skin. Later, Watson and Scarborough (4), investigating the effects of heavy external irradiation of bone, found that the periosteum is apparently very radiosensitive.

Strauss and McGoldrick (5) declared that statements to the effect that adult bone is resistant to radiation are purely relative and should not be interpreted as implying complete immunity to radiation effects. They stated that, if enough radiation is administered, the vascular, periosteal, and osseous changes will inevitably result in serious complications. These writers reported instances of fracture of the femoral neck after roentgen therapy. The involved bone had not been invaded by secondary infection, and the effects were attributed to irradiation.

Ewing pointed out that the blood vascular system of bone renders this tissue particularly susceptible to strangulation from occlusion of the haversian canals. This

[1] ad in part at the Joint Meeting of the American Roentgen Ray Society and the Radiological Society of America, Chicago, Ill., Sept. 24–29, 1944.

[2] ıce this paper was written, Dr. Camp has entered the Armed Services and is now Lieutenant Commander, United States Naval Reserve.

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susceptibility is probably due primarily to the action of secondary rays on the delicate cellular processes in the canaliculi; secondarily, to physical changes in the composition of the bone laminae, which become very brittle. The long delay in sequestration and resistance of the tissue to solution are probably the results of injury and sclerosis of blood and lymph vessels in the haversian system, periosteum, and surrounding tissues.

Nageotte (6) postulated that the bone cells are probably more susceptible than the bone lamellae and concluded that the cells are readily killed by irradiation, causing the osseous substance to go through devitalization and alteration.

Secondary radiation from bone tissue is difficult to estimate and both secondary and scattered rays increase in direct proportion to hardness of the irradiated tissue. Large amounts of calcium in bone tissue would tend to increase the secondary and scattering effects. In view of the delicate nature of the cytoplasmic processes connecting bone cells through the fine canalicular system, on which activity of the matrix of the bone is dependent for nutrition, the danger of injury to the bone by direct and secondary radiation is apparent.

The calvarium is composed of three layers of bone, a compact layer on each side of a spongy layer. It is supplied by end arterioles from the periosteum. Because both secondary and scattered rays increase in proportion to the hardness of the tissue or amount of calcium present, the structure of the calvarium is well suited for the development of radiation necrosis.

Although Stewart (7) points out that the calvarium includes the bones of the head which are altered least frequently by irradiation, one wonders whether the fact that the calvarium does not function as a weight-bearing structure, and therefore presents no symptoms due to the necrosis, has not contributed to erroneous diagnoses and resulted in failure to establish the true incidence.

Aseptic necrosis of the calvarium must be differentiated from multiple myeloma and metastatic carcinoma. A negative examination of the lowed by evidences of punched tions limited to regions which treated, and absence of any condition elsewhere in the sk biopsy whenever possible, provide ferentiation.

In many instances of necrosis of varium, the changes were inte the original observers as evidence static cancer. Possibly other have masqueraded under the sis, since the factors utilized in were not different from those used of similar nature at that time.

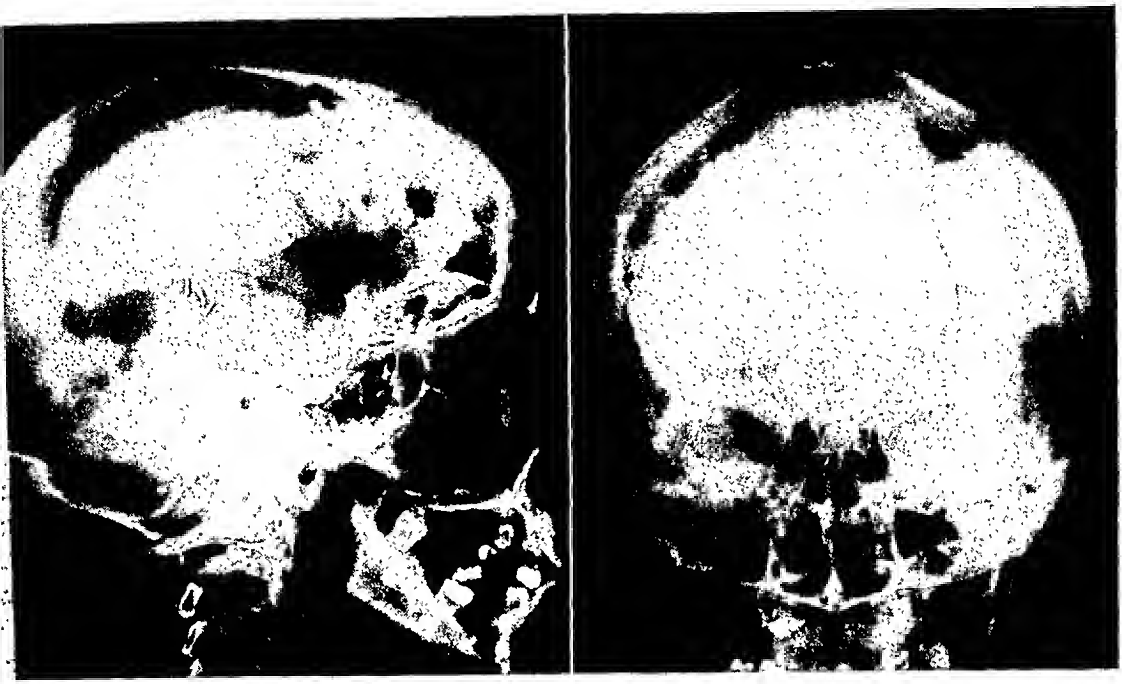
None of our five patients had referable to the necrosis. Since rium is not a weight-bearing struc condition is not as dangerous as in the hip. Considering the length of these patients survived after treatment the fact that in several instances in tion was the only therapy offered, it not seem necessary to sacrifice radi dosage because of the possibility of aseptic necrosis in the calvarium.

REPORT OF CASES

CASE I: A white woman, 43 years of age, mitted to the Mayo Clinic on Oct. 12, 192 family and past histories were not sig The present illness began two years previously the patient first noticed that she could not watch clearly. The visual disturbance disap and in July 1924 she was free from sympt two or three weeks. After this, the diffic appeared, having been aggravated by excessi ing. Nervousness, momentary dizziness, an sional nausea were accompanying sympt physician was consulted in May 1925, and tient was given glasses but received no relief ing the two months before coming to the C had not been able to recognize people or to

The results of general physical and speci logic examinations were essentially negative the exception that examination of the eyes a chiasmal lesion. There was questionable of the right hand and arm, with slightly exag reflexes. No sensory changes could be made

Exploration through an Adson pituitary proach and a decompression were perfor Dec. 1, 1925, and a tumor situated above the turcica was found. Its reddish-blue color and lar appearance suggested that it arose fr



Case I: Roentgenograms made approximately five years after original roentgen therapy was administered, howing multiple punched-out areas in the calvarium. (Courtesy Dr. F. E. Templeton, Chicago, Ill.)

oid sinus. In view of the vascularity of the ısm, its sessile character, and extent, complete al was impossible. For this reason the tumor ot touched, even to the extent of obtaining a ıen for biopsy.

toperative roentgen therapy was administered, lvarium being divided into four fields, two on ide. From Dec. 15 to 21, a total of 550 to 600 asured in air, was delivered to each field. echnical factors were 200 kv. (peak), 5 ma., n. copper and 1.0 mm. aluminum filtration, 50 stance, and 1 hour and 50 minutes time. ween March 10, 1926, and Sept. 27, 1929, the t received elsewhere an additional 10,400 r calvarium, 5,175 r to the left side, 4,375 r to ht side, and 850 r to the back (posterior). The cal factors used to administer this dosage were ., 5 ma., 0.75 mm. copper and 1.0 mm. alu- ı filters, 20 cm. distance, and 40 minutes time. onally the kilovoltage was cut to 150 and the ɔ 30 minutes; but the dosage, filter, and dis- remained the same.

were informed by letter that roentgenograms skull, made on or about April 16, 1930, re- multiple punched-out regions and, because a search was being made for a primary Later, however, when a "button of bone" moved, the histologic picture was not that ıstatic tumor but of fibrous osteitis.

nment: This is undoubtedly an ex- of radiation osteitis of the calvarium, ered approximately five years after the original roentgen therapy was admin- istered (Fig. 1).

CASE II: A white man, 38 years of age, was ad- mitted to the Clinic on Aug. 30, 1926, complaining of weakness in the right arm and right leg. The family and past histories were not significant. The present illness began in May 1925, when the patient had about five spells of jerking of the right arm and hand. These spells, which came at intervals of two days, lasted about two minutes. There was residual weakness for five or six hours after each attack. Ten weeks later weakness was noticed in the right hand and the patient experienced difficulty holding a paint brush. He also found that his hand was not as steady as formerly, especially when he tried to use a fine brush while painting signs. About the same time he noticed weakness in the right leg and footdrop, es- pecially when ascending stairs or climbing a ladder. This weakness progressed gradually. Recently he had experienced difficulty in expressing his thoughts in words.

The results of general examination were negative except for the neurologic findings. Right facial weakness and weakness and atrophy of the right half of the tongue were revealed. The lingual weak- ness and atrophy were graded 2 on the basis of 1 to 4, in which 1 represents the least and 4 the greatest degree. There was also weakness of the arm and leg on the right side. Roentgenograms of the skull were negative except for an osteoma in the frontoparietal region. The results of laboratory examinations were negative.

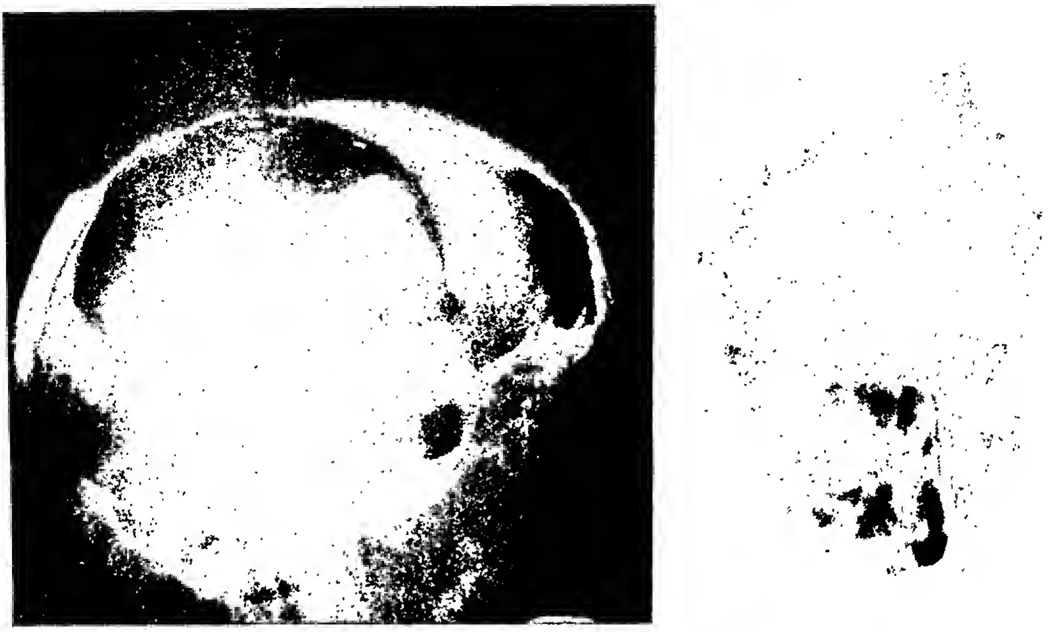


Fig. 2. Case II: Roentgenograms showing numerous small, rounded regions of rarefaction, originally t to be vascular anomalies.

Exploration and decompression over the left frontoparietal region were performed. A large osteoma over the left frontoparietal region indicated the probability of an endothelioma or meningioma. The line of incision included the osteoma and an osteoplastic flap was turned down. The dura was very vascular; on opening it, the convolutions were found to be greatly thickened and flattened. Palpation revealed some fluctuation. On insertion of trocar and cannula, 1.5 c.c. of yellow fluid was aspirated. This clouded on standing. The osteomatous region was removed during decompression. The pathologists reported that nothing of an inflammatory or malignant nature was found.

Roentgen therapy was given from Sept. 24 to 28, 1926, the calvarium being divided into four fields, each of which received 550 r. The technical factors were 200 kv., 5 ma., 0.75 mm. copper and 1.0 mm. aluminum filtration, 50 cm. distance, 1 hour and 20 minutes time. This treatment was repeated between Feb. 10 and 14, 1927.

Nothing further was heard from the patient until June 11, 1937, when he returned to the Clinic complaining of convulsions. He had no headaches which were of significance. The diagnosis was jacksonian epilepsy, adenomatous goiter, and anemia. On June 22, subtotal thyroidectomy was performed.

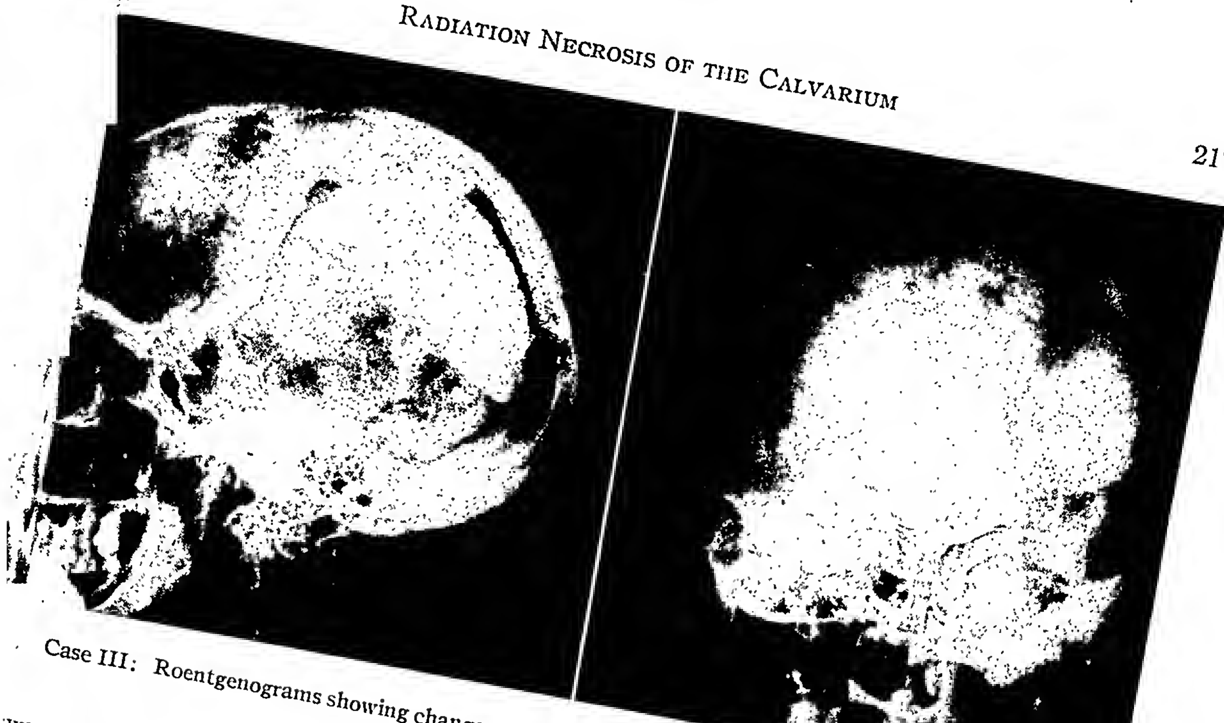
Roentgenograms of the skull on June 11 revealed the bone flap and hemostatic clips of the previous operation and also numerous small rounded regions of rarefaction in the bone flap and other portions of the calvarium. At this time these regions were thought to be vascular anomalies (Fig. 2). On later review of this case, however, it seemed that the only explanation was on the basis of radiation necrosis, since no such anomalies appeared in the original roentgenograms. Also, there was no history of trouble referable to a distinct pathologic le such magnitude. Follow-up showed that the p was well and working on May 15, 1942.

Comment: In this case radiation n sis was found approximately eleven y after administration of the initial d roentgen therapy. It had caused no s toms whatever.

CASE III: A white man, 42 years of age, w mitted to the Clinic on Oct. 18, 1927, co of headaches. The past and family histo not significant, except for the occurrence of aches of the migraine type since July 192 present illness began in the summer of 19 headaches in the occipital region, radiating d muscles of the neck. The pain was sharp a odic, recurring several times during the d January 1927, a diplopia developed sudde this, as well as the other symptoms, progresse

The results of physical examination were tially negative except for the eyes, which choked disk, 4 diopters, and bilateral weakne external rectus muscle, especially on the There were no localized signs. Roentgen the skull were negative.

On Oct. 26, 1927, exploration and decom were performed. A large osteoplastic fl turned down over the right temporoparieto region. The dura was under increased tensi exploring trocar in the occipital lobe came in with an extensive fibrous mass about 3 cm the cortex. A large decompression, measu 5 cm., was made at the base of the flap.



Case III: Roentgenograms showing changes secondary to irradiation, approximately fourteen years after treatment.

-ween Nov. 9 and 12, 1927, roentgen therapy given, the calvarium being divided into four two on each side. A dose of 500 to 520 r was red to each of these fields. The technical fac- were 200 kv., 5 ma., 0.75 mm. copper and 1.0 aluminum filtration, 50 cm. distance, and 1 hour 0 minutes time. This treatment was repeated bruary and in April of 1928, one field being ir- ed each day.

March 19, 1930, tapping of a postoperative was performed.

low-up roentgenograms of the skull were made time to time, the first to show any change being of Sept. 28, 1939. In addition to the evidence vious craniotomy and metal clips, there was sed density of the bone flap and generalized porosis of the calvarium. Roentgenograms on April 22, 1942, in addition to these findings, sed mottling of the entire calvarium with re- of rarefaction and some increased density of These changes were considered to represent c radiation necrosis secondary to roentgen py (Fig. 3). The patient had no signs or symp- eferable to the condition in the calvarium and pparently getting along well.

mment: In this case the first evidence diation necrosis was revealed by roent- grams about twelve years after the l x-ray treatment.

E IV: A white woman, 50 years of age, was ted to the Clinic on April 12, 1938, complain- failing vision for the previous eleven months. mily history was not significant. In 1924, the t had experienced visual difficulties for three months before undergoing an operation for a pituitary tumor. She received postoperative roentgen therapy. Five days after operation, there was complete return of vision in the left eye but only partial return in the right eye. The patient's general health had been good until eight or nine months prior to admission, when some memory changes developed, which recently had become more pronounced. She had difficulty remembering names and would forget to do things which she had intended to do.

Roentgenograms of the skull on April 14, 1938, revealed multiple regions of destruction on each side of the calvarium in the frontal, temporal, and parietal portions. Extensive destruction and changes in the sella turcica indicated an actively growing tumor (Fig. 4).

Right transfrontal craniotomy with extradural intracapsular enucleation of the tumor (Adson technic) was performed on April 16, 1938. The tumor, which presented a smooth capsule containing typical pulpy, reddish, granular material, was removed by blunt dissection, with the aid of a bayonet which had a cotton ball on the end, a gallbladder scoop, and a pituitary forceps. Thorough dissection was performed.

Death occurred on April 19, 1938, from bronchopneumonia. No evidence of metastasis was found at necropsy.

On inquiry into the amount of roentgen therapy this patient had received prior to coming to the Clinic, we found that 600 r had been administered to each temporal field in April and in May 1924. The following technical factors were used: 9 inch gap, 6 ma., 0.25 mm. copper filter, 12 inch distance, 25 minutes time. An additional 360 r to each of these fields had been given in June, July, and August

Fig. 4. Case IV: Roentgenogram showing multiple regions of destruction in the frontal, temporal, and parietal regions of the calvarium.

of the same year. The technical factors used for the latter treatment were 135 kv., 5 ma., and 6.0 mm. aluminum filter; the distance and time varied. The patient also received 320 r to each temporal field in March and 380 r in May 1925, the technical factors being similar to those used in the preceding June, July, and August.

After microscopic examination of a section of involved bone removed at operation, the pathologists reported that the lacunae were distinct but uniformly devoid of osteocytes. The osseous lamellae showed numerous tiny, closely grouped oval spaces presenting a moth-eaten appearance. In these regions the osseous matrix had a slightly fibrillar appearance. The pathologists concluded that the absence of osteocytes and cellular outlines, as well as the changes in the osseous matrix, warranted the conclusion of aseptic necrosis of bone.

Comment: This patient, who was treated over a period of thirteen months, received a total of 2,980 r to the right and left temporal regions. Fourteen years later roentgenograms showed evidence of multiple areas of destruction only where roentgen treatment had been applied. Undoubtedly this could be due only to the irradiation.

CASE V: A white woman, 58 years of age, was admitted to the Clinic on Oct. 10, 1941, complaining of headaches. The family history was not significant. The headaches had begun in 1924, at which time a diagnosis of pituitary tumor had been made and roentgen treatment had been advised. In 1931, the patient had a cerebral hemorrhage but recovered after treatment. Her present illness, which was characterized by headaches occurring at fi[rst] two or three times a week and later daily, bega[n] weeks before admission. The headaches, which w[ere] dull in type, generally were located in the front[al] top part of the head. They were worse at night [and] disappeared soon after the patient rose in the m[orn]ing. She had been referred to a neurologist, [a] roentgenographic examination of the head at t[hat] time had shown multiple regions of metast[asis]. She had received four roentgen treatments a [...] before admission.

Fig. 5. Case V: Roentgenogram showing bilat[eral] somewhat symmetrical regions of destruction in t[he] calvarium which coincide with fields treated previ[ously] by irradiation.

The results of physical examination were es[sen]tially negative, except for areas of alopec[ia and] slight atrophy of the skin on the scalp where [treat]ment had been administered. Roentgenogr[ams of] the skull revealed multiple regions of destruc[tion of] the cranial bones; these were bilateral and symmetrical in distribution. In view of the [history] of roentgen treatment, these changes were cons[idered] the result of circulatory changes in the bone, [repre]senting aseptic necrosis rather than metastati[c can]cer (*Fig. 5*).

On inquiry, the following information abou[t pre]vious roentgen treatments was obtained. In [...] 1924, 400 r had been administered to each [of ...] temporal fields. The technical factors were [...] gap, 6 ma., 0.25 mm. copper filter, 12 inch dis[tance], 25 minutes time. Also, in May, June, and A[ugust] of the same year the patient had received a[t an]other place, 500 r to each of these fields, the te[chni]cal factors being 140 kv., 0.5 mm. copper and 1.[0 mm.] aluminum filtration, 10 cm. portal, 12 inch dis[tance] and 40 minutes time. Treatments just pr[ior to] coming to the clinic consisted of 600 r admini[stered] to each field. The technical factors were 2[...]

a., 0.5 mm. copper, and 1.0 mm. aluminum fil-
on, 50 cm. distance, 13 minutes time.

omment: This is another example of a itary tumor which was treated by fairly vy irradiation over each parietal region. enteen years after the original treat-it, the skull showed evidence of aseptic rosis limited to those regions which had n irradiated. The necrosis was un-btedly attributable to irradiation. We not believe that the treatments ad-istered just before admission to the ic played any part in the process but have included the factors to complete report. Since this patient had had no n in the region of the bone lesions, esti-ion of their duration was impossible the finding was apparently unexpected. e such a lesion is asymptomatic, its sence becomes known only when medi- attention is sought for other reasons or a check-up.

SUMMARY AND CONCLUSIONS

ive cases of radiation necrosis of the cal-ium are reported and the condition is ewed briefly from the pathologic stand-it. The process is an aseptic necrosis to strangulation of the blood supply. gnosis is best proved by biopsy.

nce none of these five patients had pre-ed symptoms referable to the condi-, and since the calvarium does not tion as a structure of stress, we do not that large doses of radiation should be withheld from the patient because of the possibility of changes in the calvarium, especially in view of the number of years these patients had survived since treatment was administered.

In our opinion, a further review of cases of intracranial tumors treated by roentgen therapy would reveal a higher incidence of radiation necrosis of the calvarium than we have noted. Many cases which have a similar roentgenographic appearance may possibly be filed under other diagnoses.

Any patient with changes such as those described in these cases, who has received fairly large doses of roentgen therapy to the calvarium, should be suspected of having an aseptic radiation necrosis.

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Arachnodactyly[1]

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In 1896, Marfan first described the unusual syndrome now known as arachnodactyly when he reported the case of a child who exhibited extreme length and slenderness of the bones of the hands and feet. Marfan also called attention to the coexistence of other abnormalities. He considered the condition to be congenital or familial in origin and suggested for it the name of dolichostenomelia. Although this syndrome has been reported with considerable regularity by French and German physicians, arachnodactyly was not described in the American literature until 1926, when Piper and Irvine-Jones discussed the pathologic aspects of their case and stressed the frequency of the congenital cardiac abnormalities associated with this disease.

During the past year we have seen four patients with arachnodactyly, three of whom are in the same family, a father and two daughters. It is our purpose to outline briefly the more characteristic manifestations of this relatively rare anomaly, to mention a few of the more acceptable theories as to its etiology, and to report the essential differential diagnostic features of our cases.

It is safe to say that the diagnosis of arachnodactyly can be established in the majority of cases by a hasty survey of the patient as he enters the office, providing the physician is conscious of the essential features of this syndrome. The appearance is absolutely typical. For his age, the patient is tall and awkward looking, with excessively long arms and legs, long, thin, spider-like hands, meager subcutaneous fat, underdeveloped atonic musculature, and often ectopia lentis. The degree of e- tion present accentuates the bony marks, and these, in turn, serve t- phasize the disproportionate increa- the length of the extremities as com- to the trunk.

Attention is immediately focused o- delicately elongated, spider-like fi- which are sufficiently characteristic t- this syndrome its name. The appea- of the unusually thin and tapered ha- the result of a deficiency of the surro- soft parts and a considerable increa- length, without a corresponding inc- in diameter, of the metacarpal and ph- geal bones. The relaxed and elongated ments, with resultant hypermotility normal efficiency of the joints, permi- patient to perform all sorts of an- gymnastics (Fig. 1). The feet and toe- likewise long and slender. Deformiti- the joints are common. Pes planus, c- tractures, hammer toes, webbing sometimes abnormally mobile patella- cur. The frequently associated sco- kyphosis, winged scapula, and defo- of the sternum are considered to b- result of the laxity of the ligament- atonic musculature, with resultant i- quate support for proper posture.

The skull of the arachnodactylic p- tends to be dolichocephalic in c- with prominent supra-orbital ridges tal bossing, a pointed chin, and ei- prominent or broad, somewhat flat- nose. The face is usually drawn, wi- and old looking, often with a mela- expression. The ears are frequently larged and poorly supported becau- deficient and imperfectly developed a- lar cartilage.

[1] Accepted for publication in January 1945.

'he eye signs, when present, are of prime ortance in establishing the diagnosis. ›roximately 50 per cent of the patients e this major characteristic, a partial ɔcation of the lens, usually upward, ɜrally bilateral and symmetrical. The ils are small and react sluggishly. The vex edge of the lens can usually be seen in .e part of the pupil. The movements of eyeball disclose a tremulous condition :he lens and iris. The subluxated lens ften partially or completely opaque, :h adds to the visual disturbance. Be- ›e of refractive errors and interference ı accommodation, the patient usually worn glasses since childhood, and this ; to his prematurely senescent ap- ;ance.

ongenital heart anomalies frequently ımpany the disease and consist mainly patent foramen ovale and other inter- :ular septal defects. On auscultation, precordial systolic murmurs are the ; more rarely, a diastolic murmur is ›untered. With a history of fever and ng pain, the differential diagnosis be- :n rheumatic heart disease and a con- tal anomaly or both may become a problem (4). The fluoroscopic and tgenologic survey of the heart fre- ıtly will be of little diagnostic aid be- ɛ of the displacement and distortion ıe cardiac outline secondary to the ıcic deformity. Pneumonia is com- : as a result of these thoracic defects, :h predispose to infection. An absent :dimentary lobe of the lung is occasion- :eported.

:ere has been much speculation as to :xact etiology of arachnodactyly. In of the striking changes in connective- ɛ structure, bones, and muscles, the :nt-day concept favors an hereditary congenital embryologic derangement e mesodermal elements of the body 's in the early weeks of fetal life. the eyes are affected in approximately r cent of cases and are of ectodermal , a defect in a certain chromosome or ıosomes seems a plausible assump- :n an effort to postulate one cause for this anomaly. Burch, quoting a personal communication from Ida Mann, includes the following in his review of the subject.

> There is no evidence to lead us to suppose that mesodermal and ectodermal structures are segregated in different chromosomes and there is no apparent reason why the characters of the extremities should not be carried by the same chromosome as certain eye characters. Indeed, there is even slight evidence in favor of their being in close proximity since polydactyly and syndactyly are common concomitants of many ocular anomalies.

While considering the dystrophy mesodermal, Francois postulated the theory of fetal gigantism. A comparison of the roentgenologic measurements with the normal of the same age points to a partial gigantism, with the bones of the hands, and particularly the terminal phalanges, most affected. Of four cases in which autopsy was performed (4), three showed what was thought to be an increase in the number of eosinophils, with several small cysts in the hypophysis. This theory presumes an abnormally increased amount of pituitary secretion during intra-uterine life either from the gland of the fetus or of the mother. We have no direct evidence, however, to substantiate the presence of an increased hormonal secretion of either pituitary gland or an abnormal pituitary activity in postnatal life.

The bodily proportions of the arachnodactylic child, *i.e.*, the span being greater than the height, along with an increased height for the age, closely simulate pituitary gigantism before puberty. In the latter, however, the bone age is usually retarded, while in arachnodactyly, as seen in our cases, the bone age is increased by at least two years. While similar bodily proportions are found in the eunuchoid adult, retarded bone maturation and genital hypoplasia are prominent features not present in arachnodactyly. The possibility of an increase in growth-promoting factors of the pituitary which ceases at puberty is further made unlikely in the absence of an increase in lateral bone growth.

Clinical evidence has not supported the earlier theory of parental reproductive ex-

Figs. 1 and 2. Case I. Hypermotility of joints of hands and sternal depression, 10 cm. Note lack of ous tissue.

haustion nor do the pathologic reports substantiate hyperchondroplasia as the cause. Other authors have held the condition to be the result of a muscular dystrophy, an embryologic nutritional disturbance, or of the action of some toxin when the embryologic structures are undergoing specific differentiation *in utero.*

REPORT OF CASES

CASE I: A 37-year-old man was admitted to the Clinic on Dec. 13, 1943, for a general examination. For two years he had complained of progressive fatigue. During the past year, he had suffered from stomach trouble described as a sense of fullness after meals and occasional heartburn. Gaseous foods caused a sense of pressure in the chest, choking sensations, and eructation. The patient's parents, of Austrian descent, were of average height. Two brothers were over 6 feet tall and described as slender. Two sisters were 5 feet 6 inches and 5 feet 7 inches, respectively. During the patient's early childhood, a neighborhood physician commented on his unusually long and narrow hands and feet and made a diagnosis of rickets because of sternal depression. During adolescence, the patient recalled performing various feats of double-jointedness to the wonderment of his friends. He had always been tall, underweight, and poorly developed, but he had considered his health satisfactory. Hunting was his favorite sport in spite of impaired vision in his left eye since birth. His school work had been average. He had worn glasses constantly since twelve.

Physical examination showed the pa poorly nourished, underdeveloped, and muscled, but in no acute distress. His $76^1/_2$ inches, his height $72^1/_2$ inches, and 148 pounds, with little or no subcutaneous skin of the face, back and shoulders was a chronic acne. The extreme depression of of the sternum was a striking feature; a tended 10 cm. into this thoracic deformit. There were pronounced flaring of the low gins and a structural scoliosis of the spine.

Visual acuity and fundoscopic showed the right eye to be normal, but of the left revealed partial dislocation of lens upward and to the left, the patient distinguish little more than light from da

The supra-orbital ridges were pro amination of the mouth gave negative for dental caries. The normal effici markable hypermotility of the long hands was an extraordinary feature. wore a size 11 glove but stated that fit because the fingers are never long e feet were long and slender, with pes pl ity and flexion contractures of the second

The lungs were clear. The heart a larged because of the displacement to the was a soft blowing systolic murmur in the area. The blood pressure was 130 mm. sy 80 mm. diastolic. Abdominal examinati nothing of significance.

A roentgenogram of the skull did not re

mality. Fluoroscopic and roentgenographic nation showed a marked scoliosis of the dorsal with convexity to the left in the upper dorsal and to the right in the lower dorsal area. ungs were clear. Because of the scoliosis, the was in the left thorax. The stomach and duocap were normal. There was some redundancy duodenal loop.

hemoglobin was 16.5 gm. or 106 per cent. blood cells numbered 5,200,000, white blood ,450, and the differential count was normal. ysis gave negative results. The sedimentation as 11 mm. per hour.

E II: The 9-year-old daughter of the patient ped as Case I was admitted to the Clinic in . 1944, complaining of inability to gain weight asy fatigability of two years' duration. Her

Case II. Nine-year-old girl, showing elonms and legs, long tapering hands and feet, pression, and lack of subcutaneous tissue.

Fig. 4. Case II. Advanced epiphyseal development.

father stated that she had had eye trouble since birth, and a diagnosis had been made of rheumatic fever at the age of four. Since that age, her health was described as poor. Periodically she was placed at bed rest because of an unexplained fever of 102°, accompanied by weakness and fatigue. She had managed to keep up in her school work and was considered an excellent student. No history of migratory joint pain could be elicited. There were mild to moderate dyspnea and weakness on slight exertion. The patient's appetite was poor and she was given weak tea each morning to "settle her stomach."

Physical examination showed the patient to be malnourished, with poor muscular development and minimal subcutaneous fat (Fig. 3). Her height was 63 inches (normal average $50^1/_2$ inches by the Burgess chart), span 65 inches, and weight 74 pounds. The eyes were wide-set, with a slight exophthalmos, and the lenses were displaced. The upper incisors were protuberant, the other teeth carious. There was a palpable cervical lymphadenopathy. The palate was highly arched. The chest was funnel-shaped, with a slight flaring of the costal margins. The hands were exceptionally long and slender (Fig. 4). The child was able to perform many of the same gymnastics with her hands as her father. The long spindle-like legs and feet were striking. Pes planus

Fig. 5. Case III. Seven-year-old girl, showing elongated arms and legs and poor development of subcutaneous tissue.

was present. There was a generalized hypotonicity of all the muscles. The abdomen was moderately protuberant—one manifestation of a generalized hypotonicity. The lung fields were clear. There was a grade 2 systolic murmur in the mitral area with a snapping second sound. The blood pressure was 110 mm. systolic and 70 mm. diastolic.

A roentgenogram of the chest showed the lungs to be clear. Fluoroscopy showed the heart to be shifted toward the left and slightly rotated, the type of abnormality seen in a cavum thoracis deformity. Roentgenograms of the hands revealed long, spidery fingers (Fig. 4), with an epiphyseal age of twelve years and between five and nine months.

Case III: A girl, aged 7 years, was admitted to the Clinic in March 1944 for a general physical examination. Like her father and sister (Cases I and II), she had "always had long slender hands... trouble since birth." Dentition had been late... to cause her parents some concern. Her ... stated that she had always been tall and ... had complained of shortness of breath and ... when indulging in childhood games. She ha... none of the usual diseases of childhood.

The patient was underdeveloped and ...ished, with poor muscle tone and only mini... cutaneous fat (Fig. 5). The eyes were ... with a slight congenital exophthalmos. ... lentis was present. The frontal incisors were ...berant. Dental caries and marked dental ir...ity were noted. The chest was of the ... breasted type. The height was $57^1/_2$ inches ...

Fig. 6. Case III. Advanced epiphyseal dev...

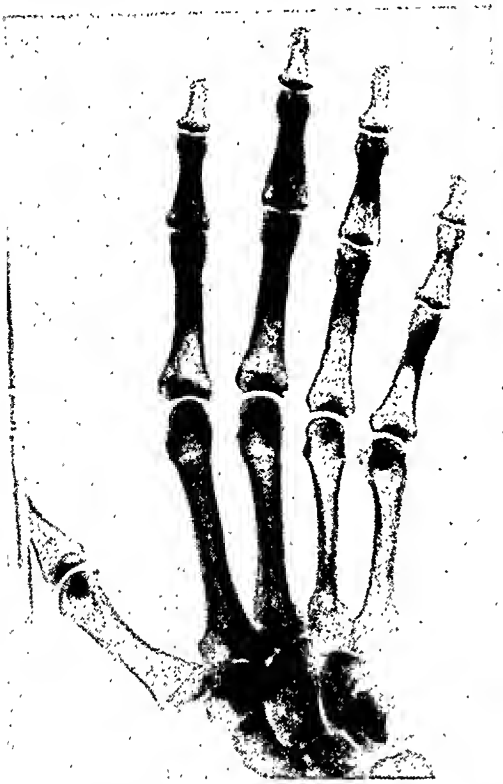
average $46^1/_2$ inches), span 60 inches, and the ... 62 pounds. The hands and feet were ... long and slender.

The lungs were clear. There was a faint ... murmur at the apex. The abdomen was ... protuberant, indicative of poor muscle t... adequate support for proper posture rather ... increase in subcutaneous fat.

Roentgenograms of the hands showed l... ing fingers, the epiphyseal age being nine ... nine months (Fig. 6). Roentgenographically ... appeared clear and the heart of normal co...

; hemoglobin was 13 gm. or 93 per cent. Red cells numbered 4,170,000 and white blood cells with a normal differential count. The Hin-est gave negative results. The sedimentation vas 15 mm. per hour. The electrocardiogram ormal except for right axis deviation.

SE IV: A 33-year-old man was admitted to the on Dec. 19, 1943, because of marked dyspnea ertion. He had been well until two years before sion, at which time he was rejected by the "because of his feet and eyes." Two months ie noticed a pressure sensation in the substernal pigastric regions, aggravated by exertion and ed by rest Shortly afterward he experienced ation, tight sensations in his throat, and a grad-



Case IV. Long tapering fingers with characteristic spidery appearance.

of 10 pounds in weight. Six months before here was swelling of the ankles of a progres-ture. The appetite was good. There were at intolerance and marked nervousness. The etabolic rate on two occasions was +19 and Lugol's solution was given by the family n for an enlarged thyroid gland, without t effect. There was no history of rheumatic syphilis. The patient's parents were Ameri-a and of normal height. Two brothers were) inches and 6 feet, respectively. One sister l to have long, slender feet and hands. The had eye trouble from birth, and as long as he member had been tall and thin for his age, g, slender hands.

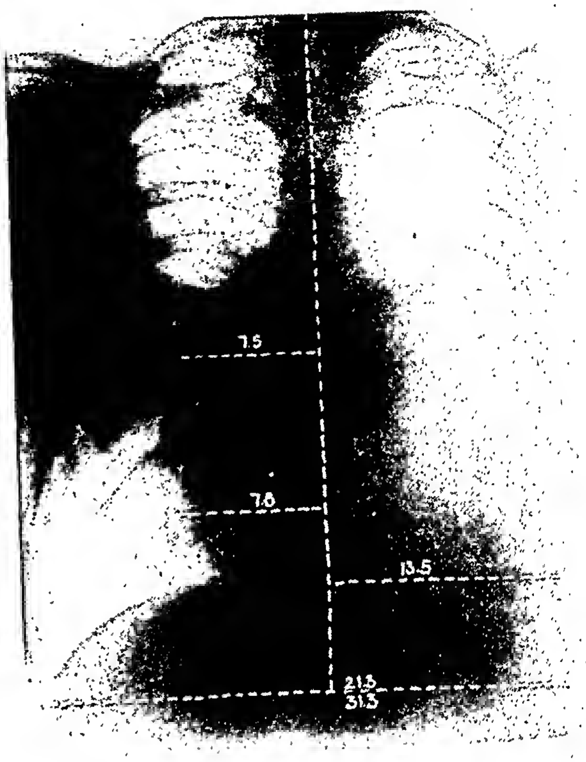


Fig. 8. Case IV. Aneurysm of ascending aorta in a 33-year-old man with arachnodactyly.

The patient was pale, acutely ill, and dyspneic, appearing much older than his stated age. His face was long and narrow, with prominent supra-orbital ridges and a large, somewhat sagging jaw. Ectopia lentis was present. The weight was 175 pounds; the height 6 feet; the span 6 feet 6 inches. There was a paucity of subcutaneous fat. The muscles were hypotonic and underdeveloped. The hands were long and gracile, with a characteristic spidery appearance (Fig. 7). The patient wore a size 11 1/4 shoe. Hammer toes were present bilaterally.

The right lobe of the thyroid gland was palpable; it measured 1.5 by 2.0 cm. and was moderately soft. The chest was flattened. There were râles indicative of congestion in both bases. The heart was greatly enlarged in all diameters (Fig. 8). Systolic and diastolic murmurs were heard both in the aortic area, with extension down the left sternal border, and at the apex. Percussion revealed dullness in the region of the base of the heart. A gallop rhythm was present. The blood pressure was 200 mm. systolic and 50 mm diastolic. The liver was palpable four fingerbreadths below the costal margin and was moderately tender. There was a grade 2 pitting edema of the ankles. A clinical diagnosis was made of aneurysm of the ascending aorta with cardiac hypertrophy and dilatation, grade 3, and congestive heart failure.

Fluoroscopy and roentgenography revealed limitation in the excursion of the diaphragm. There was an increase in the peribronchial markings at the left base, the right mid-lung field. and at the right

base. The heart was enlarged both to the right and left. There was marked dilatation in the region of the ascending aorta. The descending aorta appeared to be of average width. The cardiothoracic measurements were 21.3 to 31.3 cm., and the width of the ascending aorta was about 8 cm.

The hemoglobin was 12.5 gm. Erythrocytes numbered 4,950,000 and leukocytes 6,550. The differential count was as follows: polymorphonuclear leukocytes 62; band forms 4; lymphocytes 34. The specific gravity of the urine was 1.022; there was a trace of albumin, grade 1. No sugar, white blood cells, or casts were noted. There was an occasional erythrocyte. The non-protein nitrogen was 40 mg. per 100 c.c. The Hinton, Kahn, and Wassermann tests gave negative results. The basal metabolic rate on two occasions was +52 and +21.

The patient was treated for cardiac failure, but only partial compensation was achieved. It was felt that hyperthyroidism was unlikely but that it might complicate the picture, and thiouracil was therefore, given before the patient was discharged on Jan. 12, 1944. He was instructed to return after one month of complete bed rest but was too ill to do so.

A recent communication from the patient's physician stated that there had been no benefit from thiouracil and that death from congestive heart failure had occurred approximately six months after discharge. Autopsy could not be obtained.

COMMENT

Since American physicians have been aware of arachnodactyly as a clinical entity for only the past two decades, and since apparently it is more common than was previously supposed, it seems worth while to mention a few of the diseases with which the more striking clinical aspects of this syndrome may be confused.

The age of the patient will frequently confuse the picture. In the infant or rapidly growing child, especially without eye abnormalities but with sternal depression, flaring ribs, squaring of the head, pot belly and emaciation, this syndrome may be mistaken for rickets. However, the abnormally long and slender extremities, the absence of flared epiphyses demonstrable by roentgen examination, normal calcium and phosphorus studies, and perhaps obscure anomalies in the parents, should lead one to suspect arachnodactyly.

The symptoms of weakness, fatigue, moderate dyspnea on exertion, malnutrition, and a coarse systolic murmur in early childhood may focus attention on the cardiovascular system to the exclusion of w appear to be lesser anomalies. The di sis of rheumatic heart disease with m trition and rachitic stigmas may th made, without sufficient evidence. R matic fever, however, may occur child. The frequent occurrence of p rheumatic fever in the arachnoda child has been stressed by Young. I second case, in spite of the absence of articular involvement and a normal interval, we were unable to explai symptoms and periodic bouts of fev cept on this basis.

If the patient with congenital card cular disease is first seen when he r maturity, the frequently associated hypertrophy and dilatation, or aneur enlargement with or without frank gestive failure, present a more seriou pressing diagnostic problem. Exhau studies may be undertaken to est the diagnosis of rheumatic heart di syphilitic aneurysm, or congenital disease without due regard to the m bone, and connective-tissue find Since our fourth patient presented characteristic feature of arachnoda without other complicating etiologic tors, we believe it safe to state, in sp the absence of pathologic evidence, th had a congenital aneurysm of the a ing aorta—a manifestation of thi drome (2).

NOTE: We wish to acknowledge the ai W. P. Beetham in the study of these case give him credit for making the diagnosis in

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[D]egenerative Effects of Large Doses of Roentgen Rays on the Human Brain[1]

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[In 1]936, ONE of us with the late Dr. [Rud]olph Hartung (62) reported prelimi[nary] observations on 15 cases of brain [tumor] of various types, from the service of [E]ric Oldberg, treated with a total dose [o]f 15,000 r of high-voltage roentgen [rays]. Our first impressions were favor[able], since occasional results were noted [which] had previously been unobtainable. [In th]e twenty months from the beginning [of the] study until the time of the first re[port], no untoward effects were seen. [Simila]r treatment has been given to se[veral] cases since that time. Only re[cently] have we had the opportunity of ex[amini]ng postmortem cases showing degen[erativ]e changes as the result of such [therap]y, although the literature has, from [time t]o time, contained reports of damage [from s]imilar doses.

[Wit]h the development of the fractional [prot]acted technic of radiation therapy, [after t]he pattern of Coutard, much larger [doses] of radiation were delivered to neo[plasm]s throughout the body, including [those] of the central nervous system, than [were] used previously. The fractionated [techni]c was particularly welcome for in[tracra]nial lesions, especially in those clinics [where] aggressive radiotherapists did not [have a]dequate neurosurgical support and [where] cases were treated without the bene[fit of p]reliminary decompression.

REVIEW OF LITERATURE

[The] early reports of radiotherapy of in[tracran]ial growths showed the high mor[tality] rate of 16.9 per cent (61) directly [attributab]le to the irradiation. Less severe [reaction]e were common. Béclère (6) ascribed these untoward results to what he called the "prereaction," an acute hyperemia and swelling of the irradiated area, appearing from one to several hours after treatment and disappearing in from twenty-four to forty-eight hours. Froment, Delore, and Tassitch (32) measured the cerebrospinal fluid pressures both before and after treatment in five cases. They found increased values following irradiation, more pronounced with higher doses and when the pressure was previously high. Such developments could easily be fatal to a patient already in critical condition. The use of the fractional protracted technic, with a small initial dose which is increased by small daily increments, has reduced the danger of roentgen therapy even in cases without decompression. Thus, Cutler, Sosman, and Vaughan (14) recommended a diagnostic therapeutic test in cases of suspected medulloblastoma prior to operative exploration and felt that, with fractionation and dehydration, serious reactions could be avoided.

The tendency to deliver larger doses to intracranial tumors was stimulated by the observations of Bailey, Sosman, and Van Dessel (5) and Sachs, Rubinstein, and Arneson (55). These writers felt that larger doses were desirable, especially in the glioblastoma multiforme group, and that patients receiving such doses as a rule survived longer. Frazier and Alpers (29), in a paper on the gliomas given before the Association for Research in Nervous and Mental Disease in 1935, concluded, among other things, that a large proportion of patients had received inadequate amounts of radiation and that, with methods

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hitherto used, adequate doses could not be given because of the dangers of injury to the soft and bony structures of the head.

The universal failure of radiation therapy in those cases which seemed histologically to afford the best chance for success, based on the prophetic writing of Ewing (24), *i.e.*, cases of medulloblastoma and glioblastoma multiforme, and the paucity of clinical reports on radiation damage undoubtedly caused radiologists everywhere to attempt more radical therapy. When Dyke and Davidoff made inquiries about therapeutic radiation procedures for their book, published in 1942 (20), they found that Pendergrass was delivering up to 6,500 r (tumor dose) within six weeks in cases of astrocytoma and glioblastoma multiforme, repeating the dose if there were signs of recurrence; Sosman calculated a dose of 4,500 r to the center of a mid-line glioma: Brunschwig and Hamann gave 5,000 r (tumor dose) to medulloblastomas.

In cases of glioblastoma multiforme, Dyke and Davidoff gave from 1,000 to 1,400 r (air) to each of four portals, delivering the dose in about two weeks. They repeated the series four or five times, with intervals of four to six weeks. O'Connell and Brunschwig (49), reporting on Bailey's cases, list one patient who received 12,645 r (air) in six months; another receiving 15,248 r in fifteen months; and a third who was given 14,229 r in seven and a half months. Carty and Ray (11) delivered 6,000 r (air) at 60 kv.p. with low filtration into the open wound in one session, following radical surgical removal of a tumor. Sherwood Moore, discussing their paper, told of giving an identical dose, also through an open wound, but with 200 kv. and 1.0 mm. copper filter.

Rüsken (54) gave 2,700 r (air) through each of five portals (13,500 r total), using high voltage and 0.5 mm. copper filtration, to a tumor diagnosed by encephalography only. He repeated the same dose apparently, two and a half years later, when there were signs of recurrence. Jenkinson (39), treating Oldberg's cases, administered 15,558 r (air) over a period of three years to one patient, and to another 18,... eight series in twenty-six months. ... (31) tells of delivering three se... 9,660 r (air) each (28,980 total) to a... infiltrating precentral glioblastoma ... forme in a twenty-three-year-old ... cites three other cases in which the ... was 16,550, 22,800, and 25,000 r, re... tively. Kaplan (40) has achieved ... highest recorded dose, delivering fo... of 9,000 r (air) each and one series of ... r (air) in less than twenty-two mont... a total of 42,000 r (air). He calcula... depth dose at 25,000 r.

Some of the patients who received ... large doses died and showed degen... changes at autopsy (49), while ... showed clinical evidence of a degen... process (39). Still others, however, ... ated the treatment well and were ... clinically as long as three years la... 40). Among the latter were the p... who had received the largest doses.

That functional and morpho... changes occurred following irradia... the central nervous system of experi... tal animals was recognized soon af... beginning of radiation therapy. ... tive reviews of the literature on the ... have been made by Lyman, Kup... Scholz (43) and by Dyke and D... (20).

There were discrepant reports ... early literature as to the nature a... gree of the effect of both radium and ... gen rays. Danysz (15), Obersteiner ... and Horsley and Finzi (38), using ... observed severe vascular changes ... latter authors thought the nerve tis... unaffected except where it was da... by hemorrhage. In general, th... workers with radium noted very li... changes, the degree depending on th... Brunner (10), using roentgen rays ... cluded that the effect of radiation ... ticularly evident in the superficial ... cells of the cerebellum, while the ... vous tissues were essentially una... He found no change in the blood ... walls, but the blood vessels were ... and, secondary to this distentio...

red hemorrhages and edema of the

nan, Kupalov and Scholz (43) found ge to both systems, as did others. considered the damage to the nerve econdary to the changes in the blood y. Nemenow (47) thought that those ailed to find changes in the nerve tis- ad examined it too soon following ation. Some of the early work is diffi- o correlate with present standards of e measurement, but it was apparent he changes were directly proportion- the dose delivered (2, 3, 16, 41) and he vascular and particularly the ner- issues of the young were much more ive than those of the adult (10, 13, , 45, 48, 57).

turbances of function were noted with smaller doses than those necessary to ce morphologic changes. Nemenow vas the first to study the action of gen rays on conditioned reflexes in He found that 2 H.E.D. (1,100 r) l weakening of the conditioned re- without any morphological change. n, Kupalov and Scholz (43) found 18 to 20 erythema doses delivered onally through five portals directed posterior fossa of a dog's skull pro- more serious disturbances of these s. The reaction could be separated our periods. The first period lasted three weeks following irradiation he picture varied in different dogs. one to two days taken to recover from auma of the irradiation, their be- became quite normal, but the con- ed reflexes exhibited individual nces, both increased and decreased y being noted. The conclusion was ome increase or decrease of excita- of cortical function had occurred and hese variations fell in line with the nt physiologic constitution of the

second stage began in the second or week and continued into the fifth or longer. The general behavior appear normal, but a lowering of the spontaneous activity was sometimes noted. The conditioned reflexes always dropped to a greater or less degree, and the unconditioned reflexes might also decrease, but seldom in proportion to the marked decrease in the conditioned reflexes. Accordingly, the authors thought that the second stage could be said, with reservation, to be one of more or less reduced cortical excitability.

The third stage began with a return of all reflexes to normal; the general behavior was also normal. Since only one dog in the series reached that period, its duration could not be stated with certainty, but work with other unreported dogs also gave the impression that a time came when the natural level of cortical excitability was in no way disturbed and the animal appeared perfectly well.

The fourth stage came five or six months or more after irradiation. Definite signs of cerebral damage then developed. The last dog in the series was killed at the end of six months. The authors concluded that there was physiologic evidence indicating that, even when radiation was directed at a single part of the central nervous system, its action was diffuse; that it involved the subcortex as well as the cortex, and that there were coincident features pointing toward a vegetative nervous influence. They felt, however, that the action was not primary on the nerve cells but on the vascular system.

Nemenow (47) practically repeated the experiments of Lyman, Kupalov, and Scholz and reached similar conclusions. Davidoff, Dyke, Elsberg, and Tarlov (16), in experiments on monkeys, also observed profound physiologic and morphologic changes following irradiation of the brain and cord. These latter workers found that the effect of massive roentgen doses was especially marked in the glia and nerve tissues and, surprisingly, that changes in the blood vessels were slight in degree.

Ellinger (22, 23) made a noteworthy contribution to the problem of the origin of the nerve tissue damage. He demonstrated an optimum lethal effect for total body irradiation of the goldfish. This level was

found at 1,500 r with roentgen rays ranging from h.v.l. 0.233 to 0.9 mm. copper. Increasing the dose up to 10,000 r (air) did not influence the mortality curve. Examination of the brains, however, revealed an increase in the histopathologic changes with the larger doses, especially in the medulla oblongata. Since the fish treated with 10,000 r died on the thirteenth day after irradiation and those receiving the smaller dose were killed on the fifteenth day, the survival time was approximately equal. This Ellinger regarded as of importance since changes in the central nervous system following irradiation require a considerable time to develop, as has been noted by many workers. It appeared important, also, that *the changes in the blood vessels did not differ greatly when either dose was used.* Ellinger considered the assumption justified, therefore, that the differences in the effects of increasing doses of roentgen rays on the brain were due to direct action of the radiation on the nerve cells. The marked radioresistance of these cells was believed to account for the longer period before injury became detectable. In consequence, the damage done to the more vulnerable tissues, e.g., blood vessels, dominated the histological picture. *"But this does not necessarily imply that the injury to the nerve cells is secondary to such changes."*

The experimental evidence summarized above has a clinical counterpart. Flaskamp (27) found that, up to 1930, no brain injury had been reported with doses not exceeding 500 to 600 r. Goldstein (34) in 1930 reported on the high incidence of anomalies in children irradiated *in utero*, the treatment being directed to pelvic disease of the mothers. Druckmann (19), in 1929, reported periods of somnolence lasting four to fourteen days in 30 out of 1,100 children treated by epilation for ringworm of the scalp. The children were five to twelve years old and somnolence appeared six to eight weeks after irradiation. Ellinger (21) agreed with Druckmann that the symptoms were a sign of cerebral irritation.

Markiewicz (44) in 1935 described scalp, bone, and nerve tissue injury male of thirty-four years who had re an estimated 80 to 90 H.E.D. in a p of three years and a half (approxi 44,000 r, since H.E.D. indicates a skin dose or approximately 550 r). C Sosman, and Vaughan (14) in 1936 Béclère (7), who stated in 1928 that dangers from irradiation of the brain either immediate from edema or delay latent from radiation gliosis. Cut his associates stated, however, that delayed or latent danger of gliosis parently quite unimportant. In s our heavily treated cases, Bailey slight superficial gliosis in the spinal Normal nervous tissue is notorio sistant to radiotherapy, both in man the experimental animal." Later same article, they say: "In the exp tal animals it required excessive d radiation to damage normal centr vous system tissue and then the effe one of small hemorrhages and small of necrosis, presumably due to an e the blood vessels rather than a direct on the nervous tissue. As much as 1 at the rate of 300 r a day, throug of six portals, has been given to a without any demonstrable lesions months."

In 1937, O'Connell and Brunschw quoted the observations of Fisch Holfelder (26) on a man that had r roentgen therapy for a carcinoma temporal region. Seven years l experienced attacks of restlessness ing of heat, inability to speak, and ness and twitching of the left ha foot. Exploration showed the bra and full. There was no evidence tastasis. Biopsy revealed only a lo amyloid change which Fischer and der thought to be the result of irra

O'Connell and Brunschwig quoted Markiewicz's case, and the of Lorey and Schaltenbrand (42) Schaltenbrand (56). These rep volved two cases. The first was th five-year-old girl who was treated f

ı of the scalp. She had a complete :ion in three weeks. Three months the hair grew in on the left side but n the right. One year after treatment, :ptic attacks and left-sided weakness observed. A year later there oc- d an acute episode, with fever, con- ons, and a left hemiparesis. At the of thirteen (seven years after treat-) the left side of the body was under- oped and, although major epileptic ks were less frequent, numerous minor ks continued. Roentgen examination skull revealed changes which agreed n location with the atrophic and tel- ctatic changes in the right side of the

A well marked atrophy of the skull een and there was a superficial cal- :ion within the cranial cavity. An halogram showed the right lateral icle to be wider than the left, sug- g atrophy of the right hemisphere. and Schaltenbrand believed that oentgen rays had injured the scalp, ım, and meninges. They thought ı dural hematoma had developed in rea, injuring the cortex and giving) underdevelopment, epilepsy, and a c hemiparesis of the opposite side. y, inflammatory products in the ges had calcified. These presump- were later verified by trephination, ıymeningitis hemorrhagica being dis-

altenbrand's case was that of a y-one-year-old woman who had re- roentgen treatment for a micro- ı infection of the scalp when nine of age. During the period of treat- there was pyrexia on two occasions, ome signs of bronchitis. At fifteen of age, after the child had been ner- nd emotional for some time, she was ıt to the clinic because of delirium ver. She had aphasia, deviation of ad and eyes to the left, and a left hemiparesis. There were clonic ings of the right arm and face. Her state improved gradually, the apha- d hemiplegia disappeared, and the s of twitching of the right face and arm became less frequent. An encephalogram showed a symmetrical dilatation of the ventricles. At the age of twenty-one, the patient returned, complaining of increase in frequency of the epileptic attacks. Most of the hair of the scalp was absent; its skin was thin and atrophic. Roentgen films showed patchy defects in the cranium, and in one place there was some flaky intracranial calcification. Schaltenbrand thought that the roentgen rays had injured the cranium and brain at the age of nine and that, after a latent period of three years, an encephalitis-like illness resulted, which gave rise to the right hemiparesis and epileptic seizures.

O'Connell and Brunschwig also presented several of their own cases. The first two patients had not received radiation therapy and served as controls. The third patient was a man of 45 with signs and symptoms of a right frontal lobe tumor. Craniotomy by Dr. Percival Bailey revealed an extensive glioma. A biopsy was taken and a decompression was done. The microscopic picture was that of a cellular glioma, classified as a protoplasmic astrocytoma but with evidences of malignancy. From April 24 to Sept. 12, 1933, the patient received 12,645 r (air) through multiple portals, at 200 kv., with 1.0 mm. copper and 1.0 mm. aluminum filter. Transitory erythema and permanent epilation occurred. The patient returned to work. The decompression remained soft until March 1936. The patient then "lost interest in things," a left hemiparesis appeared, and the decompression became tense. He received 630 r of roentgen therapy but gradually passed into coma and died on April 27, 1936. Autopsy was performed eleven and a half hours later, but the brain had been fixed previously by arterial injection. The right frontal region was 25 per cent larger than the left and contained a large tumor. Histologically, this was more cellular and of a somewhat more malignant type than at biopsy three years before. The authors summarize the findings as follows: Definite and generalized degenerative changes were

present with a marked increase in lipochrome substance within the cells. The nerve cells were affected most and the neuroglia to a lesser extent. The blood vessels were for the most part unaffected. There was no evidence of any mesodermal reaction, though fat-laden macrophages were to be found around most of the small vessels.

The fourth patient in the series, aged 32 years, had signs and symptoms of a left temporal lobe tumor. Craniotomy by Dr. Bailey revealed a deep mass; a biopsy and a decompression were done. The microscopic appearance was that of a protoplasmic astrocytoma with some cellular polymorphism and multinucleated cells. There was also thought to be oligodendroglia in the growth. Between April 7 and 18, 1933, the patient received 8,178 r (air) through multiple portals; between May 29 and July 5, 1934, he received 7,250 r (air). A severe dermatitis of the scalp followed the second treatment. The attacks continued, although at longer intervals and, apart from this, the patient was at first considerably improved. Later, he lost his appetite and displayed weakness, listlessness, and loss of energy. The decompression stayed soft and flat. Vomiting occurred and there was numbness of the left hand and leg. Eventually drowsiness ensued and death occurred Jan. 25, 1935. At no time was there bulging or tenseness of the decompression. An autopsy was done less than three hours after death. In the left hemisphere was a large mass of abnormal tissue extending from the anterior portion of the left temporal lobe to within 2 cm. of the occipital pole. One cyst, 2 cm. in diameter, was present in the center of the mass and there were numerous surrounding cysts. There was considerable edema of the left hemisphere. Histologic examination revealed an extensive degenerative process with some areas of marked astrocytic proliferation, undoubtedly tumor. There was no evidence of malignant transformation. The author's summary of findings is as follows: "In this brain, which had received larger doses of radiation than the previous one, more pronounced degenerative ch[anges] were present. The process affected [not] only the nerve cells, but also the a[stro]cytes, microglia, and possibly the oligo[den]droglia. The blood vessels were inv[olved] to a slight extent only. The ch[...] dendrosis and myelin destruction of [the] temporal lobe might be accounted f[or by] the presence of the tumor but cert[ainly] not the widespread degenerative ch[anges] affecting all parts of the cortex."

The fifth case was one of medull[oblas]toma cerebelli. The patient, a male 4 years old, entered the hospital i[n Oc]tober 1932 with a history of unsteadi[ness of] gait of six months' duration. A c[linical] diagnosis of a tumor of the vermi[s was] made. At operation, a typical med[ullo]blastoma was found. A biopsy s[pecimen] was taken and a decompression [done]. The child received 13,789 r between [Oct.] 11, 1932, and April 17, 1934, 200 r per sitting being given either rather [con]tinuously or in series with varying re[st pe]riods. Irradiation caused the symp[toms] to disappear and later had the same e[ffect] on the lumbar pain which develop[ed in] April 1933 and again in March 1934. [Sub]sequently, irradiation proved una[vailing] and the child died in February [...] Postmortem it was found that the [tumor] had spread widely through the sub[arach]noid space. "Widespread changes o[f the type] previously described were present. [They] affected the nerve cells, neuroglia, [microg]lia and even the blood vessels. The [nerve] cells showed more definite evide[nce of] degenerative changes here than i[n the] other case, no doubt due to the age [of the] patient."

The sixth case of O'Connell and [Rus]schwig was also one of cerebellar [me]dulloblastoma, in a child of five and [...] years. The patient received 14,220 r from Sept. 26, 1933, to May 7, 1934 [and] died less than one month following th[e] treatment. "The changes," said the [au]thors, "resembled those in the br[ain of] Case 3, the nerve cells being main[ly af]fected. These were swollen and [...]

, their nuclei being displaced and ily stained."

their discussion, O'Connell and Brunig definitely eliminated the possibility any of the changes which they atted to the effects of radiation were the t of either postmortem changes or resence of the tumor. They referred e work of Stern (60), Casper (12), and di (9). They also called special aton to their two cases of medulloblas. The patient who had lived almost a following irradiation showed much er changes than the one who died n one month of the treatment. They ved with Schaltenbrand that the time a has elapsed after irradiation may be nportant factor in the production of ieration. Individual variations of tivity to radiation, as with other e, was also considered to play a role.

mmarizing the changes in the various of tissue examined, O'Connell and schwig observed that in only one brain there well marked alterations in the ilar system in both the cortex and lla; in the remaining cases, no vascuaction other than slight thickening of iedia was seen. They concluded that med certain that in none was the lar change primary or the factor reible for the alterations in the nervous itself.

1939, Sosman (58) stated that the ers following irradiation in treatment uitary adenomas were real but rare. ad not observed a case of edema of ain, which is so often mentioned as a bility. He believed the nerve tissues ilts would stand dosage up to 6,000 r y one area; dosage should be below evel to avoid injury to the vessels and quent fibrosis, gliosis, or necrosis.

1940, Pendergrass, Hodes, and Groff reported 3 cases of carcinoma of the in which large doses of radiation were ed by radiation damage. All three its showed clinical, operative, and ogic evidence of bone infection. A le strangulation of the blood vassystem within the bone by radiation, as mentioned by Ewing (25), was considered to be an etiologic factor. It was likewise pointed out that destruction of the normal protection mechanism of the body may occur with large doses of radiation. In one patient bone necrosis developed. All had symptoms of increased intracranial pressure and signs referable to the area of treatment. In all cases the first craniotomy showed a focal subdural abscess. One patient died of a purulent encephalomeningitis and one of a streptococcic meningitis, obliterative endarteritis, and brain softening. This latter patient had a large abscess below the site of treatment and a malignant metastasis from the scalp to the contralateral temporal lobe. The authors were assured by Dr. B. J. Alpers, pathologist, that the findings were primarily due to infection, with little evidence to suggest brain degeneration of the type seen following irradiation.

Dyke, in a discussion of the paper by Pendergrass and his associates, stated that he had had several cases in which an epidural abscess developed during roentgen treatment for a glioma, weeks to months after operation. In addition, Dyke had treated 31 patients in the operating room with large doses of roentgen rays delivered at one session. He gave from 2,000 to 3,000 r at 200 kv. Five patients had died from infections, which number, he says, "is altogether too great for a hospital in which good aseptic technic is used and a large amount of brain surgery is done." Also, infections occurred in 3 of 10 monkeys irradiated with large doses of roentgen rays, and death from meningitis or cerebral abscess followed. Some of the monkeys that were irradiated showed no immediate effects but later exhibited degeneration of the brain.

In 1940, Sosman, discussing a paper by Kaplan (40) on irradiation of brain tumors, stated that experiments had been made that convinced him that if more than 6,000 r were given in the brain itself in any one series of consecutive treatments, there was an approach to brain damage; with over 6,000 r, brain damage resulted, and with

10,000 to 12,000 r in one series the patient might be killed. In children, he felt that the safe limit was 3,000 to 4,500 r in one series.

Jenkinson and Oldberg (39), in 1942, reported a case of glioblastoma multiforme in which treatment was begun in September 1936 and totalled 15,558 r (air) over a period of three years, most of it during the first year. Five portals were used. There was rapid improvement following the first series and this continued until July 1939. Then, although the patient felt well, he had difficulty in talking and in controlling head movements, and he lacked judgment. A neurological examination by Dr. Roland Mackay revealed no evidence of the original symptoms of tumor. Dr. Mackay attributed the neurological findings to brain atrophy, which he believed to be due to radiation. The application of roentgen rays in this case was intensive and quite general, according to the authors.

AUTHORS' CASES

Our own report concerns 6 patients. In 4 of these the tumors were histologically verified prior to irradiation. The other two undoubtedly had tumors but they were deep-seated, and specimens could not be obtained at operation. All received postoperative roentgen therapy. From three to five portals were used, from 5 to 10 cm. square. The initial dose was usually 150 r, increased to 300 r within three or four treatments. (In Case I doses in excess of 250 roentgens were not tolerated.) One portal was treated each day. Five or six treatments were given each week, if possible, until the series was completed. The shortest series ran 32 days, totalling 9,000 r in air and 6,150 r tumor dose; while the longest series took 106 days for 14,840 r (air) to the skull (8,809 r tumor dose) and an additional 2,700 r to a posterior nasal lesion.

Three separate machines were used. The voltages were 190, 200, and 220 kv.p., with filters of 0.75, 0.5, and 1.0 mm. of copper, respectively. The half-value layers were 1.0, 0.75, and 1.56 mm. of copper.

The dosage rates were 20, 49, and
minute (air). The highest dose
one portal was 3,200 r (air) deliver
thirty-two days. Usually transient
red erythema occurred, and was
by epilation and dry desquam
Moist desquamation was not
The epilation was permanent.

Following irradiation, there was
a period of good health (except in
Within a period of a few months to
two years there developed evidence
damage to the brain. Three of the
tients came to autopsy.

CASE I: A white male, aged 44, was
the Illinois Neuropsychiatric Institute
1942, with difficulty in speech and right-
ness present since the preceding Novem
had noticed clumsiness of his right hand
1941, and by November there was a defin
sided paresis, with subjective right
personality deterioration in the nature of "
ness" and faulty judgment, and some diffi
choosing his words. These symptoms led
mission to another hospital, where a left
craniotomy was done on Jan. 13, 1942, and
seated glioblastoma multiforme of the pari
was verified histologically. There was no
at extirpation, and the bone-flap was allowed
loosely to afford decompression. The post
course was uncomplicated save for a
convulsive seizure on the twelfth postopera
No further seizures occurred and the pati
transferred to the Institute for deep x-ray
three days later.

On admission the patient was conscious
interested, with a fatuous smile on his face
no apparent distress. He had papilledema
diopters, a complete right homonymous
sia, a complete right hemiparesis, right-
don hyperreflexia, patellar and ankle clo
right Babinski sign. He exhibited such
aphasia that he could speak only in mono
and he was usually incontinent of urine and

From Feb. 11 to May 27, 1942, 57 roen
treatments were given through right
parietal, vertex, and frontal portals, 10 cm.
Treatments were scheduled daily, but the
dition of the patient caused intervals of
days without treatment. The total dose in
13,000 r, while the calculated dose to the
the tumor was 7,758 r. There was no
clinical improvement. Early in the course of
tion therapy the patient was somewhat
responsive, and at times his decompression
rather tense. Later he returned to his
state and then slowly declined. Soon his
sponse was a weak smile at the physician

e became slowly and progressively more -ted and unresponsive until his death on Oct. 3, nine months after operation and four and months after completion of roentgen irradia- At no time following the completion of radia- erapy was there evidence of pressure in the ve wound. The resemblance to a patient ıg from general paresis in its late stages was ıtly noted.

nortem examination was made five hours death. Gross examination of the brain, was fixed in a 4 per cent solution of formalde- showed herniation of the left gyrus cinguli area of surface extension of tumor some 5 × ı diameter in the left parieto-occipital region. mor proved microscopically to be a typical toma multiforme. Examination also disclosed ıent pneumonia of the upper lobe of the left uppurative bronchitis, generalized atheroma- generation of the aorta, coronary arteries and alves, and cloudy swelling of the liver.

esentative sections of the cerebral and cere- cortex on both sides were stained, in this e, with thionin by Nissl's method, Bielschow- ethod for neurofibrils, Oil Red-O for fat, and method for myelin sheaths. Practically ell in the cortex was filled with fat—a veri- saster. The nerve cells, glia cells, endothelial nd even the ependyma all contained fat. the depths of the white matter the fat was ıt, especially in the endothelial and adventi- . The lipochrome substance in the ganglion s easily visible, in the sections stained with throughout the cortex and in large amounts. the Betz cells still contained Nissl sub- nd as a whole appeared normal, there was y marked chromatolysis in large numbers of er ganglion cells throughout the cortex. ssl substance was replaced by vacuoles. vas little, if any, chronic cell change in ıre of shrinkage or sclerosis, but nearly all was evidenced by dissolution of tigroid e, replacement by the lipochrome pigment, g and eccentricity of the nuclei.

he fat stain, the capillaries were clearly out- the fat contained in their walls. There lent, throughout the cortex and white mat- perivascular infiltrations about the small composed chiefly of lymphocytes and mac- containing greenish blood pigment. The od vessels appeared relatively normal.

ptomeninges showed moderate thickening infiltrations with lymphocytes and espe- ny pigment-filled macrophages. Beneath mater were occasional small focal collec- ymphocytes.

ains showed no massive lesions of the white out broken up myelin sheaths were easily ıt in the cortex, running their interrupted ross the section. Others were extremely with many knobby excrescences.

The pathological alterations were as pronounced in the cerebellum as in the cerebrum.

Comment: This was the first brain to be examined thoroughly. In view of the extent of the lesions, we determined to make a more careful examination in subsequent cases, after optimum fixation.

CASE II: A 30-year-old white woman was first admitted to the Illinois Neuropsychiatric Institute on Dec. 16, 1941, because of increasing irrationality and stupor over the preceding four days. The history indicated that the patient had suffered generalized convulsive seizures since a fall on the ice at the age of 7 and some time later had begun to have right-sided focal motor seizures as well as right-sided sensory seizures, in the nature of formication. Persistence of the seizures, despite phenobarbital medication for four years, led to her admission to another hospital, where the findings of mental retardation, slowness of alternating movement on the right, right lower facial weakness, spastic weakness and agraphesthesia of the right lower extremity were recorded. On May 5, 1938, a left central osteoplastic exploration was made and a large subcortical cyst containing some two ounces of black syrupy fluid like "dirty motor oil" was evacuated. The cyst wall contained dark grayish, friable tumor tissue but, because of the central location, extensive dissection was not attempted. Microscopic examination showed an astrocytoma undergoing malignant change. The postoperative course was uncomplicated and from May 16 to May 25, 1938, a total of 1,995 r of radiation (air) was given by a technic comparable to our own. The tendency to convulsions persisted despite intensive medication, and they continued to occur at about monthly intervals. The patient was otherwise well during this period of three years and seven months until four days prior to admission, when she became increasingly irrational, actively hallucinatory, and mute. Her family physician suspected recurrence of increased intracranial pressure and referred the patient to the hospital.

Examination showed the well healed operative scar and its associated decompression to be quite flat and under no tension. The patient was at times entirely mute and negativistic, at others silly and verbose, and had frequent hallucinations. She was very dehydrated, but despite this, the remainder of the neurological examination was negative. She was felt to be in an acute psychotic episode and made an excellent recovery after treatment of the dehydration. Because of the malignant appearance of the previously incompletely removed tumor tissue, deep x-ray therapy was instituted. The patient completed the course as an out-patient, being quite well and having good insight into her recent psychotic episode. She was given, from Dec. 22, 1941, to March 16, 1942, 47 roentgen-ray treatments for

a total of 15,120 r (air) equally divided between five portals (left anterior frontal, posterior occiput, left and right lateral temporal, and vertex). Portals 10 cm. square were used. The dose in the center of the tumor site was calculated at 8,661 r.

The patient continued to be quite well, receiving 1 grain of phenobarbital each night, and had only a rare light seizure but grew weak and tired and apathetic until suddenly, in November 1942, she became paralyzed over the entire right side and severely aphasic. She grew progressively more stuporous and, with the onset of incontinence, was readmitted to the hospital on Jan. 11, 1943.

Examination on this last admission showed complete epilation, depression of the operative decompression, complete right hemiplegia, right-sided hyperreflexia and pathological reflexes, and severe aphasia. The patient was conscious but responded poorly. It soon became necessary to feed her by tube and, though there was never any evidence of pressure on the decompression, she became slowly weaker and died March 19, 1943, after two months of this all too familiar vegetative existence, one year after completion of x-ray therapy.

The brain was removed immediately after death and showed, besides a slight herniation of the left uncus, a ragged cavity some 4.0 × 3.5 cm. in diameter, containing viscid xanthochromic fluid in the left cerebral region. Blocks were immediately cut from numerous areas of the cortex of both cerebral hemispheres, from the cerebellum, basal ganglia, and brain stem. From each area portions were fixed in Zenker's fluid, Bouin's fluid, 4 per cent aqueous solution of formaldehyde, 95 per cent alcohol, Mueller's fluid, Weigert's gliabeize, Cajal's formalin-bromide, and Regaud's fluid.

Examination of the rest of the body revealed antemortem thrombi in the iliac veins, but nothing else of importance. In the brain was a multicystic lesion in the left cerebral hemisphere, extending in the centrum ovale from anterior to the head of the caudate nucleus posteriorly to the level of the splenium of the corpus callosum.

Microscopic examination showed in the cerebral cortex a universal and severe loss of Nissl substance with darkening and eccentricity of the nuclei. Many cells were totally devoid of cytoplasmic color and many were vacuolated. The Purkinje cells of the cerebellar cortex were observed to have suffered less, and the Betz cells were scarcely affected. The leptomeninges over the cerebral cortex generally were moderately thickened and infiltrated with the cells of a chronic inflammatory exudate, amounting in certain small localized areas to a chronic meningitis, through the appearance of perivascular infiltration of lymphocytes and histiocytes. Fat was demonstrable in droplets in every type of cell from ganglion cell, astroglia, microglia, to adventitial cells, endothelial cells, and ependyma in all the portions examined. The extent of the process was generalized, excessive fat being demonstrable even in the Purkinje cells of the cerebellum and the ... glia cells of the upper cervical cord.

There was also observed a diffuse and ... increase in the fibrillary glia, amounting ... areas to a veritable gliosis. Many cytop... were seen, and clasmatodendrosis was ... evident in the Bergmann cells of the cereb... tex, where the fragmentation was extrem... Though fragmentation of the astroglia of th... bral cortex was evident, particularly the p... mic ones, it was not nearly so striking as ... in the Bergmann cells. The impregnati... not very successful for demonstration of ... droglia and microglia, but ameboid glia ... matodendrosis were well shown thereby. ... examples of varicose, fragmented, and sw... lin sheaths were evident in all areas of th... and somewhat more so in the subcortic... chowsky's method showed considerable ... and fragmentation of the nerve fibers of th... cortex.

The pathologic alterations described ab... more intense in the cortex of the left hemi... the central region but were present throug... cerebrum and the cerebellum.

The region of the multicystic lesion was ... contain remnants of tumor consisting of ... glia cells with pyknotic nuclei and sm... plasm. There were extensive degenerat... much overgrowth of connective tissue and ... blood vessels. No mitosis was found, but ... were multinucleated. Except at the tumor ... blood vessels appeared fairly normal.

Comment: Such psychotic episodes ... irradiation of brain tumors have be... scribed in several cases by Bened... Inflammatory-like changes follow... radiation have been noted by other... cially Lyman, Kupalov, and Scholz ...

CASE III: A male, 52 years old, was ... mitted to the Illinois Neuropsychiatric In... Oct. 23, 1941, complaining of severe left-... ache for eleven months. It was impossible ... an adequate history but, since the devel... the headaches, he seemed to have underg... of alternate euphoria and depression. In ... or four months prior to his admission he ... pounds in weight, experienced pain in th... and ear, and had daily morning nosebleed... and at times became unconscious. He ... same period he had numerous seizures ... seen for the nasal bleeding in Septembe... time only an ulceration and deflection of ... septum were visible. Examination ... showed marked tenderness of the entire ... prominent veins in the left temple, and ... left because of the blood-clogged nar... lateral papilledema.

Ventriculography, Oct. 29, 1941, reveal...

g lesion in the left frontal lobe and was fol- immediately by a left frontal craniotomy. h a cortical incision, a large mass was en- ed on the medial and inferior aspect of the d much of it was removed by suction, so that f of the orbit was widely exposed. No de- ssion was left and the dura mater was closed

The tumor proved to be a colloid carci- and similar tumor tissue was later obtained by from the nose, high on the left posterior wall. immediate postoperative course was un- ated, and the patient was discharged the h postoperative day, Nov. 14, 1941, after ray therapy had been started. He was re- d ten days later for ligation of the left fem- in because of left popliteal thrombosis de a rapid recovery. He continued his x-ray as an out-patient and from Nov. 14, 1941, 10, 1942, he received 49 roentgen treatments tal of 14,840 r (air) to right and left parietal, vertex, and occipital portals, 10 cm. square. se in the center of the intracranial tumor was ed at 8,809 r. In addition, 2,720 r were de- to three facial portals, mainly the left an- This radiation was not considered in calcu- he intracranial dose. Some of the cranial were angulated toward the posterior nasal

atient failed to return to the dispensary ex- e shortly after completion of the roentgen and was not seen again until April 8, 1943, was again admitted to the hospital because rent headaches and cachexia. The history d that he had improved considerably in the nd summer after the roentgen therapy, he had continued to have frequent mild . In December 1942, headaches in the left nd temporal regions had recurred and he ome weak, apathetic, and bedridden. Se- niting had supervened shortly prior to ad-

ination at this time showed the tumor in the easily visible, necrotic, bleeding, and foul. as also evidence of orbital invasion, in the ard, nodular masses palpable in the medial ior portion of the left orbit, displacing the terally, though there was no impairment cular movements or pupillary reactions, papilledema. There was some secondary ophy bilaterally, and tendon hyperreflexia ight but no other localizing neurologic he patient was emaciated, cachectic, and t dehydrated; his state of conscious- such that he could be aroused only with ficulty to make unintelligible sounds in a e but could not be induced to co-operate. ent was supportive and palliative. The ecame progressively weaker and died on 1943, one year and seven months after and one year and three months after com- roentgen irradiation.

At necropsy there were found metastases in the pleura, liver, and right ilium, patchy broncho-pneumonia, healed tuberculosis of the right pulmonary apex, prostatic hyperplasia, cholelithiasis, and fibrous adhesions of the right pleura.

The brain and spinal cord were both removed immediately after death. The tumor had invaded and destroyed both cribriform plates and the sphenoid bone back to the tuberculum sellae and involved the ethmoidal and sphenoidal sinuses, as well as the left frontal sinus, which was markedly ballooned. The roofs of both orbits were intact, but that on the left was pushed upward. The tumor had invaded the left frontal pole and orbital gyri, but had not crossed the midline, and extended back to involve slightly the caudate nucleus and globus pallidus. There was a light brownish leptomeningeal infiltration over the inferior surface of the brain in the sylvian fissure and on the dorsum of the cerebellum and vermis.

Representative sections from different areas of the brain and spinal cord were taken and placed immediately in numerous fixatives (Mueller, Bouin, Zenker, 10 per cent formalin, Cajal's formalin-bromide, Regaud, 95 per cent alcohol, Weigert's gliabeize). Preparations were made by freezing, paraffin, or celloidin technic and stained by Masson's trichrome, hematoxylin-eosin, thionin, van Gieson, Holzer, Weigert-Pal, Oil Red-O, and methylene blue-eosin, and impregnated according to the methods of Cajal, Hortega, Bielschowsky, Perdrau, and others.

The thionin-stained sections of this brain showed a considerable and widespread thickening and light cellular infiltration of the leptomeninges extending even into the cervical region. The infiltration consisted chiefly of lymphocytes and pigment-filled macrophages. In the pia mater and the molecular layer of the entire cerebral cortex, there was a mild cellular increase consisting mainly of microglia. There were innumerable cells of this type whose processes were beautifully outlined by the contained blood-pigment stained bright green by this method. There were obvious light perivascular infiltrations of lymphocytes and pigment-filled macrophages throughout all areas of the cerebrum and cerebellum, more marked in the frontal areas than elsewhere.

The nerve cells of the entire cerebral cortex had suffered widespread and severe damage in the sense of marked lysis of Nissl substance and nuclear displacement toward the apical dendrite. These changes were more pronounced than in any of the other brains examined; they were equally severe on the side opposite the lesion and were present throughout the hemispheres. With the Nissl stains, the greenish-yellow lipochrome substance was easily visible in a large proportion of the cells. The Betz cells showed less chromatolysis than the lesser nerve cells, but the fat in them was abundant and easily visible. These changes were again most severe in the frontal cortex and least of all in the occipital re-

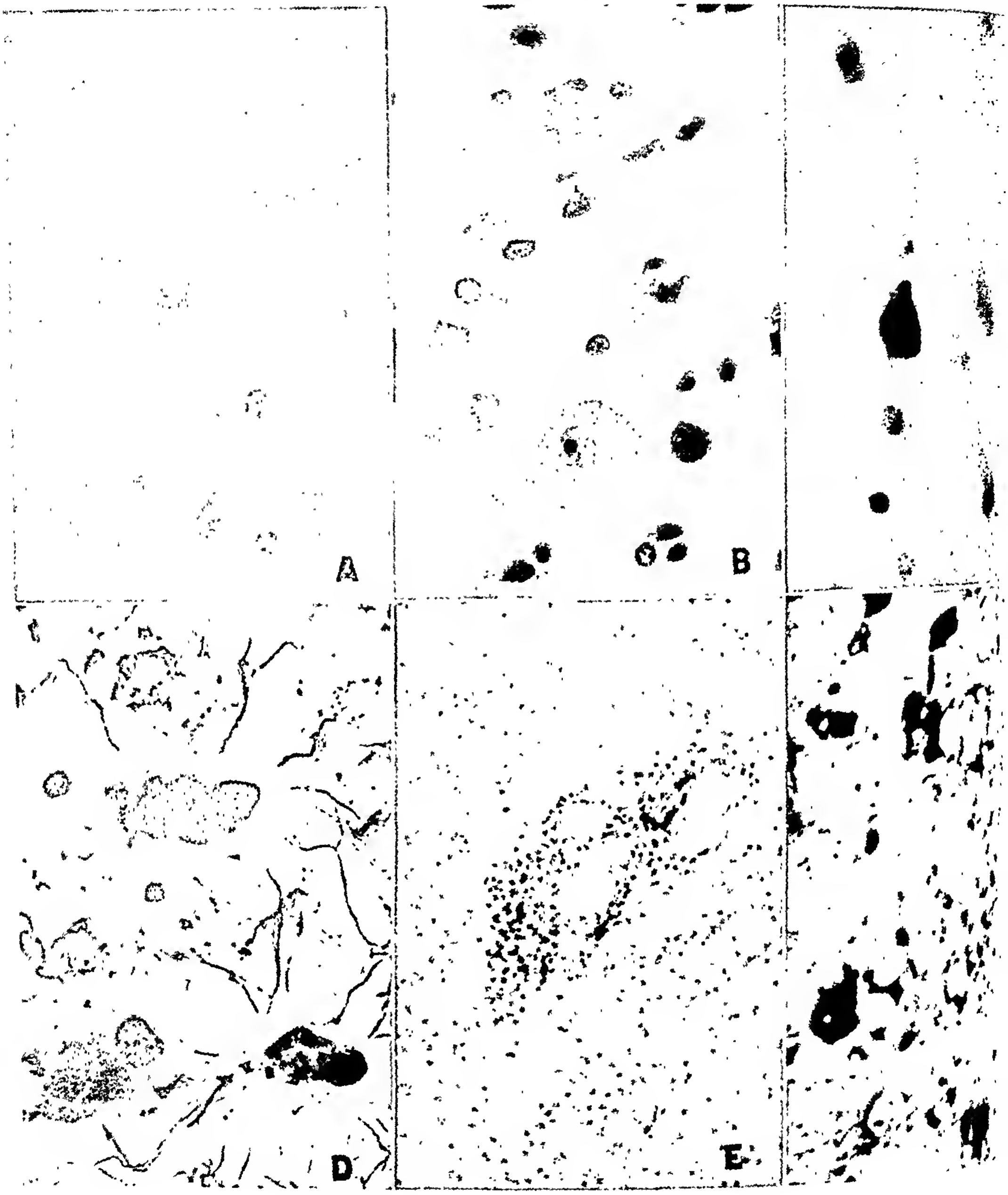

Figure 1

A. Cortical neurones from the cerebrum. Large vacuoles, Nissl granules gone, nuclei diffusely stained. Thionin stain.
B. Cortical neurone from the cerebrum. Swollen, Nissl granules gone, nucleus heavily stained. Thionin stain.
C. Cortical neurones from the cerebrum. Shrunken, nuclei displaced. Case II. Thionin stain.
D. Fibrillary neuroglial cells from the subcortex with swollen bodies and displaced nuclei. Case II. F silver carbonate.
E. Perivascular infiltration with lymphocytes and plasma cells in the cerebral subcortex. Case II. stain.
F. Clasmatodendrosis of protoplasmic neuroglia from the cerebral cortex. Case II. Hortega's silver

gion, though clearly present in the latter. There was everywhere an obvious and widespread increase in the oligoglia.

The sections stained with Oil Red-O showed an overwhelming amount of fat contained in cells of all types and in all regions. These fatty deposits were definitely more severe than in any of the previous cases, were very evident in the cervical re spinal cord, and even involved the lumb largement. Fat was observed in large a in the Purkinje cells and in every nucle of the entire brain with the possible excep substantia nigra, whose cells appeared rel preserved. There was a widespread and

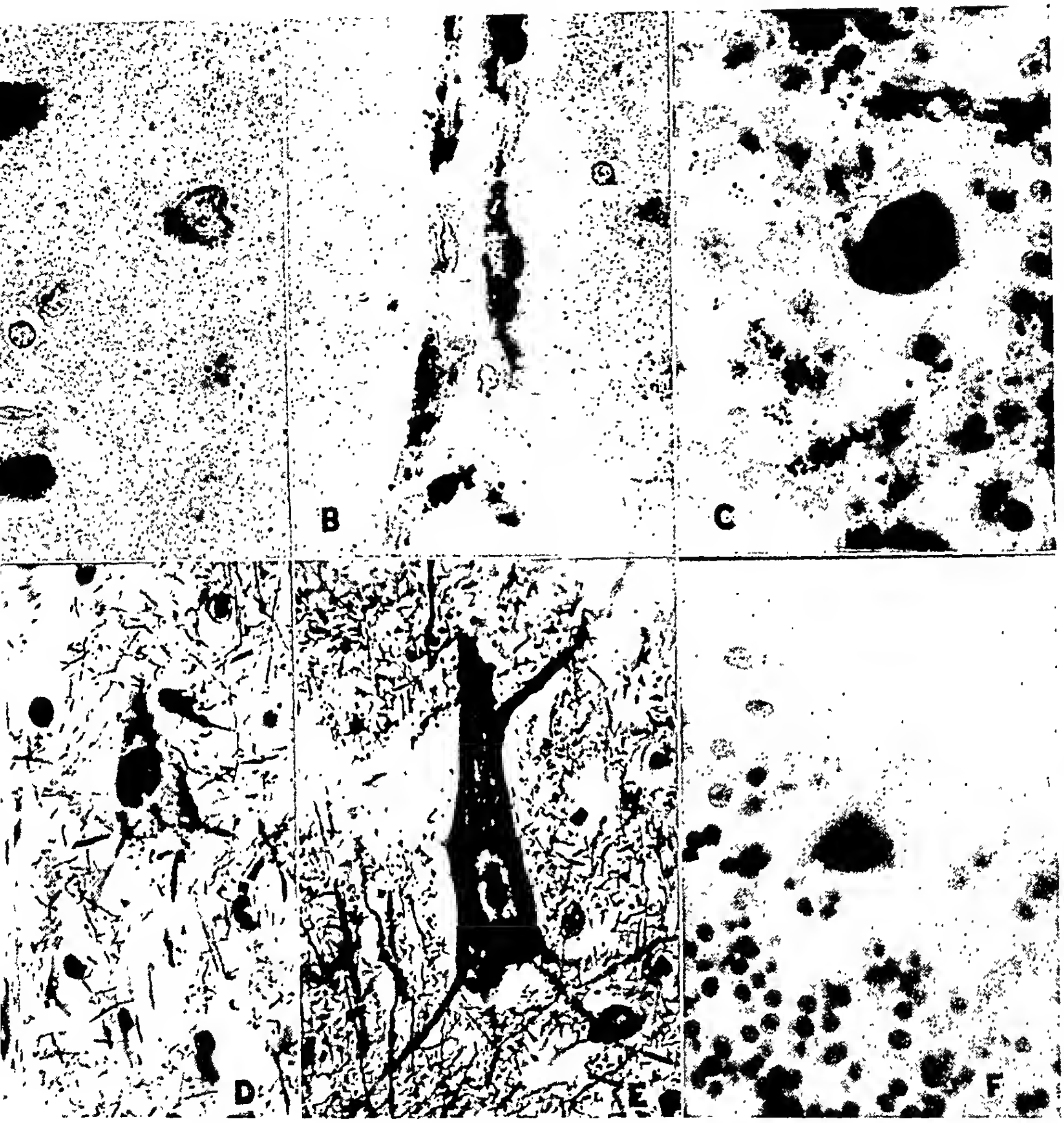

Figure 2

ortical neurones from the cerebrum. Heavy accumulation of fat. Case II. Oil Red-O.
ortical capillaries in the cerebrum. Heavy deposits of fat in the endothelial cells. Case I. Oil Red-O.
urkinje cell layer of the cerebellum (molecular layer to the left). Heavy deposits of fat in a Purkinje
n surrounding glial and endothelial cells. Case III. Oil Red-O.
ortical neurone from the cerebrum. Displaced nucleus. Neurofibrillae destroyed. Case I. Bielschow-
thod.
ant Betz cell relatively normal. Case I. Bielschowsky's method.
urkinje cell. Nissl granules gone, nucleus displaced and heavily stained. Case II. Thionin stain.

the astrocytes, with many giant forms and l instances of clasmatodendrosis. Hortega's showed many microglia throughout the brain ently greatly increased numbers, containing ets and green pigment. In none of the sec- re any pathological changes found in the ssels themselves, either of the leptomeninges tissue, except for the above noted perivascu- ation.

Summary of Pathological Alterations

From the foregoing account, it is evident that the pathological changes following irradiation of the brain are widespread and affect all of the cellular elements. The nerve cells of the cerebral cortex are almost universally degenerated, the least change

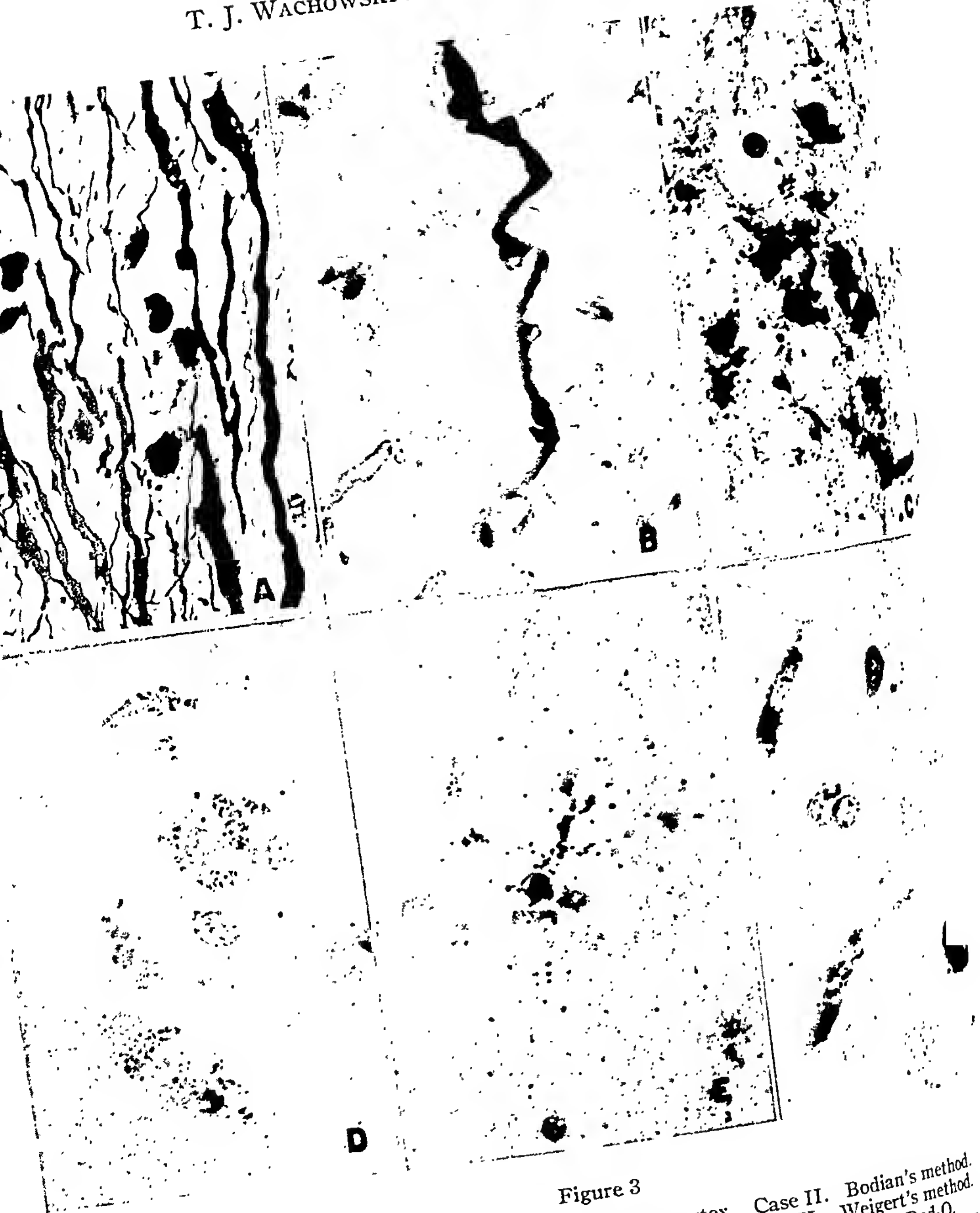

Figure 3

A. Swollen and fragmented axis cylinders from cerebral subcortex. Case II. Bodian's method.
B. Swollen and fragmented myelin sheaths in cerebral subcortex. Case II. Weigert's method.
C. Fatty deposits from fragmented myelin sheaths in cerebral cortex. Case II. Oil Red-O.
D. Fatty deposits in neuroglial cells of the plexiform layer of the cerebral cortex. Case I. Oil Red-O
E. Microglial cell in cerebral subcortex containing fatty granules. Case II. Oil Red-O.
F. Cortical capillaries in cerebrum containing fatty deposits in endothelium. Case III. Oil Red-O

being seen in the large Betz cells of the motor cortex (Fig. 2, E). The nuclei are almost always diffusely stained (Fig. 1, A, B, C) and eccentrically situated (Figs. 1, A, C and 2, A, D); the neurofibrillae are disintegrated (Fig. 2, D); the tigroid substance is gone (Fig. 1, A, B, C); the cytoplasm is swollen (Fig. 1, B), shrunken (Fig. 1, C), or more often vacuolated (Fig. 1, A); excessive amounts of fat have accu (Fig. 2, A). The neuroglial cells, the protoplasmic cells of the co fragmented (Fig. 1, F) and the fi neuroglial cells are swollen (Fig. fat has accumulated in their cyt (Fig. 3, D).

There is an increase in the nu microglia cells of huge size with the

laden with fat (Fig. 2, C and 3, E) eenish pigment. The capillaries (Fig. and other small blood vessels have ssive amounts of fat in the endothelial adventitial cells (Fig. 2, B). The in sheaths are swollen (Fig. 3, B) and nented, giving rise to accumulations t in the white substance (Fig. 3, C). nerve fibers also are swollen and nented (Fig. 3, A). In the adventitial s are accumulations of fat-laden macges and also lymphocytes and plasma (Fig. 1, E). In the leptomeninges are nulations of lymphocytes, plasma and macrophages. There is, therea universal degenerative change afg all parts of the brain and all its ar elements, even of the cerebellum . 2, C and F).

DISCUSSION

at is the significance of the changes bed in the preceding paragraphs? cannot be due solely to the presence eoplasm, nor the effect of increased ranial pressure. We have con1 these observations by examination, same manner, of brains containing astomas but not subjected to irradiar having only minimal or moderate ation, and have found no such uni. cellular disaster. There are often r degenerative changes in the neighod of the neoplasm and even degenn of nerve fibers at a distance. changes associated with the presence eoplasm have been often described 0, 53).

n the presence of metastases from a ant growth elsewhere in the body ot produce such universal degenera33, 36). The cachexia in the third ight account for the fatty infiltration involved the lumbosacral spinal s well, but even fatal starvation does oduce the other changes noted (35). possible causes such as poor fixaostmortem necrosis (59, 63), intoxietc., do not come into question. forced to conclude that the changes result of excessive radiation.

Fig. 4. Case IV. Note sunken decompression.

This conclusion is strengthened by the clinical course in other cases, also, in which we have not been able to do a necropsy. We cite as examples three such instances.

CASE IV: A woman aged 40 was admitted to the Illinois Research and Educational Hospital on Jan. 9, 1936. For nine years she had suffered from convulsions without focal signs so far as could be determined. Lately her vision had failed and she came, on this account, to the eye clinic, where it was found that she had choked optic disks. The optic disks were elevated 3 diopters. There was a right lower facial weakness and possibly an aphasic disturbance, although it was difficult to be sure because the patient spoke only Polish and was very unco-operative. On Jan. 14, 1936, she had a convulsion which began in the right face and neck. On Jan. 28 a ventriculogram showed displacement of the ventricles to the right. The following day a left osteoplastic exploration disclosed a large tumor lying just below the surface in the parietotemporal region. Biopsy was done and the bone removed so as to leave a large decompression. The diagnosis was astrocytoma, and x-ray irradiation was begun.

From Feb. 22 to April 22, 1936, the patient received 51 roentgen-ray treatments for a total of 15,000 r (air), almost equally divided between right and left temporoparietal, frontal, vertex, and occipital portals Portals 10 cm. square were used in the

right and left temporo-parietal regions, and 5 cm. square over the other areas. The depth dose was calculated at 6,403 r. Near the end of the course of treatments, the aphasia improved and the patient spoke Polish and, later, English fairly well.

The patient was discharged from the hospital on Feb. 22, 1936, and was followed in the out-patient department. On Oct. 5, 1936, she was feeling well; the decompression was soft but bulging. She remained without complaints, doing her work and apparently as well as usual—although it was impossible to get any detailed account from her or her family—until Dec. 24, 1942, when she began to have twitching of the right side of the face accompanied by inability to speak. From that time, at least, she began to decline rapidly. On Jan. 7, 1943, when she was readmitted to the hospital, she was found to have a right lower facial weakness, was apathetic and unco-operative. The decompressed area was markedly sunken (Fig. 4). All the hair of the scalp was absent. There was bilateral optic atrophy. The patient was asthenic, apathetic, and demented. She was discharged Jan. 21. When last seen, on July 8, 1943, her condition was unchanged.

Comment: When the patient first came to the clinic she was thought to have some aphasia but was otherwise mentally quite alert. Now, not only does she again have difficulty with speech, but she is also profoundly demented. This dementia cannot be attributed to an extension of the neoplasm.

CASE V: A woman aged 31 was admitted to the Illinois Neuropsychiatric Institute on July 23, 1941. About four months prior to admission she saw double. The vision of the left eye decreased, and soon that of the right, also. Two weeks before admission, she began to have severe headaches. She had a bilateral papilledema and greatly reduced visual acuity but no definite localizing signs.

On July 26 a ventriculogram was made and on the same day a left parietal osteoplastic exploration was undertaken. No tumor was disclosed but a decompression was done. Recovery was prompt, and x-ray irradiation was begun on the seventeenth postoperative day. A series of 62 roentgen treatments was given from Aug. 12 to Oct. 9, 1941, a total of 15,155 r (air) being equally divided between right and left lateral, vertex, occipital, and frontal portals. Ten-centimeter-square cones were used. The calculated depth dose was 8,693 r. The patient tolerated the treatment fairly well and was discharged on Oct. 10, 1941, feeling well. Her decompression was full but not bulging.

The patient was followed in the out-patient department and remained well and alert, doing her housework, until about August 1943, when she began to complain of lethargy and failing memory. From that time she declined rapidly. She w[as] admitted on Dec. 9, 1943, at which time she w[as con]fused and disoriented and her memory wa[s ...] She was lethargic and responded very inade[quately] to questions. The hair was absent from th[e ...] The decompression was sunken. There wa[s gene]ral weakness and emaciation. The te[ndon re]flexes were brisk. The patient was scarcely [able to] walk, with a hesitant spastic gait.

Pneumoencephalography, Dec. 16, 19[43, dis]closed slight enlargement of the lateral [...] ventricles, increase of air over the hemisph[eres ...] slight displacement of the ventricles to th[e ...] The patient was discharged on Dec. 19, 19[43 ...] continued to decline and died on April 2[...] home. There was no necropsy.

Comment: This is another insta[nce of] gradual physical and mental deteri[oration] without increase of intracranial pr[essure] setting in after months of improve[ment].

CASE VI: A 12-year-old girl was admitted [to the] Illinois Neuropsychiatric Institute on May [...] For three months she had suffered from h[eadache] and vomiting. For the last week her vis[ion had] failed; her gait was unsteady. She had a [...] papilledema, nystagmus, inco-ordination of [ex]tremities, and a staggering gait.

A diagnosis of tumor of the cerebellum wa[s made.] On May 8, 1941, a suboccipital exploration wa[s done] but no tumor was found. Because of difficu[lty in] breathing afterward, due to continued intr[acranial] hypertension, a Frazier needle was inserted [into the] right lateral ventricle on June 4, and x-ray t[herapy] was begun.

Between June 2 and July 3, 1941, this pa[tient re]ceived 9,000 r (air) evenly divided betwe[en ...] posterior and right and left occipital p[ortals ...] cm. square. The tumor dose was calcu[lated ...] 6,150 r. A moderate erythema occurred [...] to the ears, but otherwise the skin toler[ated the] treatment well. Epilation was complete [and per]manent.

The patient was discharged on June [...] comfortable, without the ventricular dra[in ...] irradiation was continued. She remain[ed ...] well except for occasional headache until S[...] 1943, when she had a convulsion followed [...] The convulsions were repeated, and th[e ...] stated that they were preceded by bright [...] the central visual field. She was readmitte[d to the] hospital on Oct. 18, 1943.

There was no hair over the occiput and s[...] tal region. The suboccipital decompre[ssion was] soft and not bulging. The visual acuity wa[s ...] and the visual fields were concentrically co[ntracted.] The optic disks showed secondary atr[ophy but] no swelling. There was no nystagmus or [...] of cerebellar dysfunction. The patient see[med some]what dull and apathetic.

Oct. 25, 1943, an encephalogram disclosed dilatation of the lateral cerebral ventricles, ally the right, and a considerable increase of ıchnoid air over the occipital lobes (Fig. 5). atient was discharged on Oct. 30. Last seen y 27, 1944, she had had no more convulsions taking phenobarbital and her condition was vise unchanged.

mment: The epileptic attacks beginwith visual aura give evidence of iron of the occipital cortex, and the ıoencephalogram shows clearly local hy. Usually in a pneumoencephalo-, the occipital region has small narulci and is the least well filled of the subarachnoid space. In this case, emainder of the cerebral cortex was radiated except as the rays may have through from the occipital region.

Fig. 5. Case VI. Roentgenogram made after spinal injection of air. Note the unusual accumulation of air in the occipital region.

e of the six cases here reported ed strikingly similar clinical courses ring irradiation. The patients imd and, indeed, appeared quite normal eriods of eight to twenty-six months, ps even longer in Case IV. Symptthen set in pointing to brain damage. varied from the convulsions and disturbances in Case VI to the seoss of normal cerebration resulting in etative state and death in Cases I, II, II.

three highest tumor doses were 8,809, and 8,910 r. The patient received 8,693 r enjoyed twenty-two ıs of good health from the time irran was ended. She died eight months the onset of symptoms of deteriora- The patients receiving 8,809, and r were normal only ten and eight ıs, respectively, following the comı of irradiation, and died five and four s from the onset of decline.

patient received 7,758 r in the tuıt failed to return to normal for any iable period, passing from the ishness" caused by the tumor diinto the vegetative state of the raı degeneration.

patients received tumor doses of and 6,150 r. The one that received of 6,403 r was an adult. She returned to her normal level of mentality for many months following irradiation, and she was still alive at the end of eighty-nine months. She declined rapidly following her first convulsion and within three months was in a vegetative state. It may be significant that in this case the lateral portals were 10 cm. square but the frontal, vertical, and occipital portals were only 5 cm. square. This spared some of the cerebral tissues from irradiation and reduced the depth dose. This technic was dropped in favor of larger portals when we found at autopsy much more extensive lesions than had been expected on the basis of the operative findings.

It might be suggested that the smaller portals are preferable, since they spare some of the brain tissue from irradiation. Such an argument is not entirely valid, however, when one considers the great length of many of the nerve fibers which course extensively throughout the brain. Lyman *et al.* (43) and Davidoff and his associates (16) found that localized irradiation caused widespread degeneration. This would suggest that the total dosage to the nerve tissue at any one point is the determining factor in causing degeneration. Modifications of the technic are important, therefore, only as they influence the dose

TABLE III: PRIMARY NEOPLASMS OF THE CENTRAL NERVOUS SYSTEM: SURVIVAL IN RELATION TO TU…

	Postoperative-postirradiation Survival	Maximum Dose	Minimum Dose	…
GLIOBLASTOMA MULTIFORME				
5 patients alive	9–47 mo. Average 25 mo.	15,600 r	6,500 r	
20 patients dead	1–64 mo. Average 14.3 mo.	10,560 r	3,980 r	
ASTROCYTOMA				
15 patients alive	12–64 mo. Average 45 mo.	19,780 r	4,150 r	
6 patients dead	2–44 mo. Average 17 mo.	14,800 r	6,500 r	
ASTROBLASTOMA				
1 patient alive	24 mo.	...	...	
1 patient dead	6 mo.	...	...	
EPENDYMOMA				
2 patients alive	17–40 mo. Average 28.5 mo.	7,300 r	6,880 r	
1 patient dead	9 mo.	...	...	

would be subjected to irradiation. In the light of the warnings by others relative to the unhappy effect of irradiation upon the brain, for a time a rather conservative program was followed. This consisted in several series of 3,000 to 6,000 r, in air, divided among several ports, at three-month intervals until the desired total was reached. So little constitutional reaction was encountered that we soon determined to proceed on a bolder course, with the result that we now commonly administer total doses of 10,000 to 15,000 r (in air) at 50 cm. F.S.D. with Thoraeus filter, the half-value layer being 2.0 mm. Cu. Filtration of 1.0 mm. Cu and 1.0 mm. Al has been used occasionally.

The tumor dose, calculated by means of observations on a wax phantom, approximated 90 per cent of the total roentgens in air for the frontal lobe lesions, 83 per cent in the temporal and parietal group, and 72 per cent (76.5 per cent for children) in the occipital. These figures are, of course, influenced by the location of the tumor and the number of ports which are practicable.

Initially two fields are each given 100 r per day. If no significant symptoms or signs appear by the end of the first week or ten days, the daily dose is increased to 150 r per field. The scalp will tolerate a considerable amount of radiation suitably filtered and given in consecutive doses. Like other skin areas, it will not t… repeated insult at monthly, quart… even yearly intervals, as well as a larg… spread over six weeks. We have h… good fortune not to encounter any… untoward early or late constitutional e…

In fact, we have experienced som… cious glee in referring patients who … observation to one of our good frie… that he might observe not only th… parent effect of the irradiation in c… of a tumor, but particularly that he … see the lovely hair which had regrow… lowing 2,500 r or more to each of four… One of the female patients has been e… ally pleased in that her former o… medium-brown hair has regrown in … lent quality, very dark brown, … black, with a natural curl. A… mother is quite proud of her dau… fine blonde hair, which on regrowth re… its former quality and curl. Amo… earlier cases, where two or three seri… administered, some permanent ef… has ensued.

Mental State: Many of these p… are in a sorry mental state, as well as … cal condition, prior to operation. … terrors or violent temper episodes … patient with a temporal lobe tu… well known. Others are stuporous … atose, unmanageable or unco-ope… This disturbed mental state frequent… sists postoperatively. Such patients …

: IV: PRIMARY NEOPLASMS OF THE CENTRAL NERVOUS SYSTEM: COMPARATIVE TABULATION OF SURVIVAL PERIODS

	Elvidge, Penfield, and Cone Postoperative	Dyke After operation and irradiation	Present Series After operation and irradiation
astoma multiforme	8.5 mo.	19.3 mo.	25.0 mo. (alive) 14.3 mo. (dead)
:ytoma	36.2 mo.	48.7 mo.	45.0 mo. (alive) 17.0 mo. (dead)
lloblastoma	...	22.3 mo.	22.0 mo.

radiated with some caution, and, of se, under constant supervision. The ovement which we have observed r treatment in a satisfactory number hardly be attributed solely to the de- ression of the craniotomy and removal ich portion of the tumor as has been ble surgically. The mind clears, co- ation returns, and although some sia or ataxia remains, as would be cted after the damage of the neoplasm its partial surgical removal, the mental of these patients is appreciably to edly improved. One locally eminent ., with an astrocytoma of the left oral lobe, was able to return to his bers and adjudicate wisely for some een months following his first two s of irradiation. A business executive, a right frontal glioblastoma, who had me quite unmanageable, returned to ffice in order to arrange his affairs but ed to manage his business for almost ty months. A young clergyman, with strocytoma of the right frontal lobe, completed his theological studies at seminary and has adequately carried is pastoral duties during the fifty-six ths since operation and irradiation. her clergyman, with a right fronto- tal glioblastoma, was able to return to arish for most of the thirty-five months h elapsed before his death this past ner.

umor Dose: As will be noted in Table there is no notable direct relationship een the size of the tumor dose and h of survival. There is some indica- that the minimum tumor dose should eater than 6,000 r for the astrocytoma 7,500 r for the glioblastoma. The lloblastomas and ependymomas are insufficient in numbers to warrant any major deductions, save that tumor doses of 6,000 to 7,000 r or more are probably required to affect these neoplasms.

As we have indicated, there is no clinical evidence so far to cause us to hesitate to increase the tumor dose, where possible, to 10,000 or 15,000 r. The limitation will be that of the scalp and possibly the vascular structure of the skull. For the latter reason, we would favor the higher dose in an initial and single series.

Survival Period: Many factors enter into an assay of the results of surgical and radiation therapy of any neoplasm. In malignant tumors of the brain and brain stem, the hazards of the anatomic location and function of the structure involved increase the danger afforded by the type of lesion.

It is to be expected that glioblastoma multiforme will show an almost reciprocally low proportion of survivors as compared with the longevity of a large majority of patients with astrocytomas An appreciable number in either group, and of those with medulloblastoma, will succumb within a few months, in spite of surgical intervention or roentgen therapy. This accounts for the somewhat comparable average length of life for those who died. The high mortality in the first year after diagnosis and surgical intervention, with or without irradiation, is inevitable.

If, on the other hand, the span of comfortable and relatively useful life of the remaining groups can be extended, the effort has been worth while. A tabulation of survival periods in three similar series, relatively comparable save for irradiation, is presented in Table IV.

Surgical removal of the tumor should

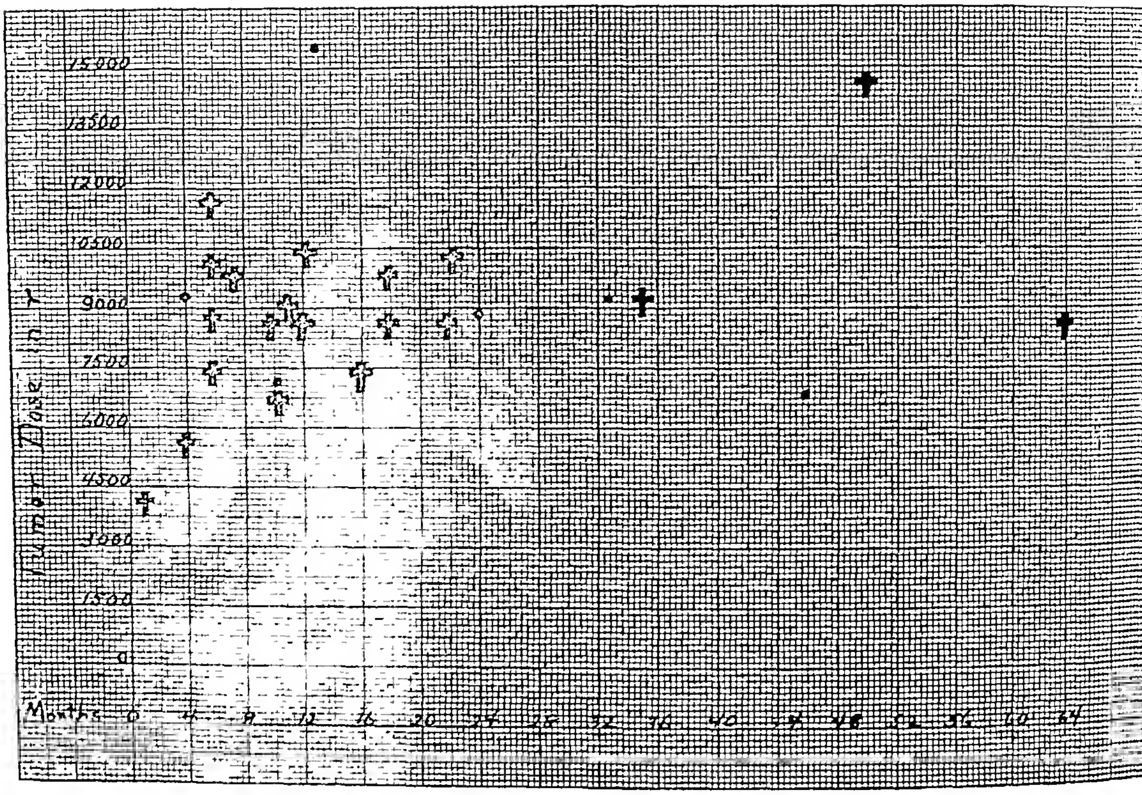

Fig. 1. Glioblastoma: postoperative-postirradiation duration of life, in months. Patients still alive are designated by a dot; those dead by a cross.

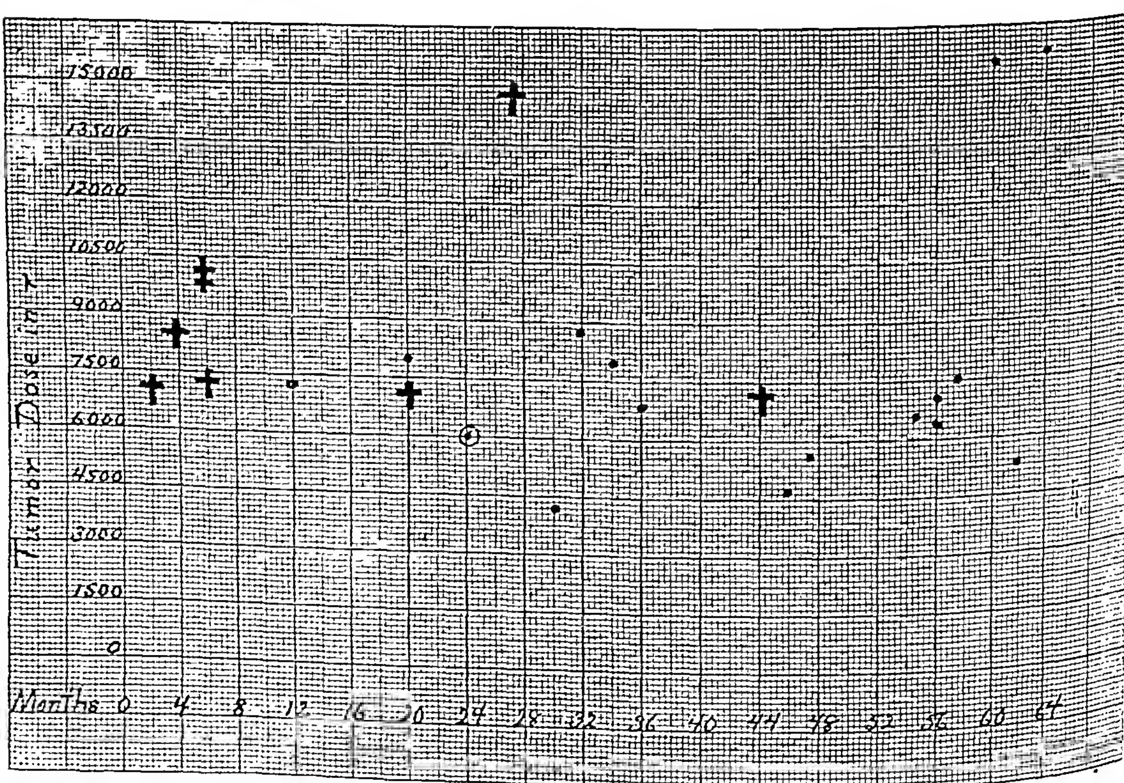

Fig. 2. Astrocytoma and astroblastoma: postoperative-postirradiation duration of life, in months. Patients with astrocytoma still alive are designated by a dot; those dead by a cross. The corresponding symbols for astroblastoma are a dot within a circle and a double cross.

TABLE V: PRIMARY NEOPLASMS OF THE CENTRAL NERVOUS SYSTEM: CLINICAL RESULT AND LONGEVITY FOLLOWING TREATMENT

	Cases	Survival: Postoperative and Postirradiation Maximum	Minimum	Average
(A) Glioblastoma multiforme				
Alive and well	2	47 mo.	9 mo.	23.5 mo.
Alive with residual symptoms	2	...	...	11.0 mo.
Alive with marked symptoms	1	...	...	47.0 mo.
Dead	20	64 mo.	1 mo.	14.3 mo.
(B) ASTROCYTOMA				
Alive and well	12	64 mo.	12 mo.	44.6 mo.
Alive with residual symptoms	3	...	...	46.0 mo.
Dead	6	44 mo.	2 mo.	17.0 mo.
ASTROBLASTOMA				
Alive and moderately well	1	...	...	24.0 mo.
Dead	1	...	...	6.0 mo.
(C) EPENDYMOMA				
Alive and well	2	40 mo.	17 mo.	28.5 mo.
Dead	1	...	...	9.0 mo.
MEDULLOBLASTOMA				
Alive and well	3	40 mo.	12 mo.	29.0 mo.
Alive with residual symptoms	1	...	...	20.0 mo.
Dead	3	7 mo.	6 mo.	6.6 mo.

be accomplished in so far as its nature, location, and extent will permit with safety of the patient. Some will, of course, have residual damage from the tumor—paralyses, aphasia, etc. Patients with no progression of such signs, or improvement, are considered as well as could be expected and, for purposes of tabulation (Table V), are shown among the "alive and well," or "alive and moderately well." These will ultimately show symptoms or signs of further damage or of recurrence. So far, however, we have not detected any secondary degenerative or late effects of irradiation.

We have previously commented on the high mortality early in glioblastoma multiforme, which reaches its peak in the first six to twelve months (Fig. 1). Similar analysis of the survival period of the astrocytomas (Fig. 2) suggests a relatively parallel mortality during the first twenty-four months after operation. Some improvement with the larger roentgen dose is indicated in the survival over thirty-six months. This may be a true shift or simply a variant due to the small statistical sample. We shall not lose hope of improvement, but consider the majority of losses inevitable.

A further analysis of the three series (Table VI) suggests that, with more thorough irradiation, a distinct shift has developed toward longer survival in a higher proportion of the cases, most notable in the periods over fifteen months.

TABLE VI: PRIMARY NEOPLASMS OF THE CENTRAL NERVOUS SYSTEM: COMPARATIVE RESULTS

	Elvidge, Penfield, and Cone (1935)	Dyke and Davidoff (1944)	Peirce, Cone, Elvidge, and Tye (1944)
GLIOBLASTOMA			
Postoperative-postirradiation survival			
12 mo. or more	31.8%	40.5%	56%
15 mo. or more	13.6%	23.9%	44%
20 mo. or more	9.1%	10%	32%
ASTROCYTOMA			
Postoperative-postirradiation survival			
12 mo. or more	90.5%	81%	85.7%
24 mo. or more	66.6%	64.3%	71.4%
36 mo. or more	33.3%	38.1%	52.4%
48 mo. or more	14.6%	28.5%	33.3%

Further follow-up and analysis must be accomplished with particular reference to those cases in which death has closed the chapter and gives an absolute line of cleavage from which any major deductions may be made.

SUMMARY

1. Definite clinical improvement is afforded by roentgen therapy of malignant

primary neoplasms of the brain and brain stem.

2. Twenty-five of 60 patients with complete follow-up over the past four years are either "alive and well" or "alive and well save for residual symptoms."

3. No deleterious effects chargeable to the roentgen therapy have been observed in the series. Primary regrowth of hair has been excellent. No late degenerative changes have been observed following total tumor doses of 15,000 r.

4. *Glioblastoma multiforme* continues to show a high mortality rate despite increasingly large doses of roentgen radiation. Probable improvement in longevity is indicated by the analysis of the data. Tumor doses in excess of 7,500 r will be required.

5. The effect on *astrocytoma* is not so marked as would be expected, but this should not discourage treatment similar to that recommended for glioblastoma.

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Neurosurgical Procedures for the Relief of Pain in Advanced Cancer[1]

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RARELY SHOULD a defeatist attitude toward intractable pain be entertained without an investigation of the possibilities of relief by means of surgery. This applies especially to patients with incurable cancer because to them the actual and potential penalties involved are insignificant when compared with the relief of pain which they may expect from surgical treatment.

In this country alone, cancer takes 160,000 lives each year. Of this number of patients passing through the terminal stages of the disease, comparatively few require neurosurgery. Local treatment of the growth, together with other measures such as x-ray therapy and the administration of analgesic drugs, tides the majority of patients over until there are complications causing rapid failure or until cerebral metastases occur which may not only raise the threshold of pain but also make the patient indifferent to his condition.

It is in those patients with intractable pain, whether this comes early or late in the course of a malignant neoplasm, that neurosurgery has a wide field of usefulness. When pain becomes unbearable, relief by surgical means should be considered before allowing the patient to become addicted to opiates. At present, the number of patients being treated in this manner is small, but when the possibilities and advantages of surgery are more widely appreciated, a greater number will be benefited. Opiates may control pain for a brief period, but this interval is shortened as tolerance to the drug is increased. Furthermore, gastro-intestinal disturbances are common and may be as disquieting as the pain itself. The general well-being of patients relieved of pain by surgical means is far better. Often they are able to pursue a gainful occupation for months or years. Moreover, treatment of the formerly painful areas can be pushed to the limit.

CHORDOTOMY AND TRACTOTOMY

Any operation for relief of pain due to cancer should not only produce anesthesia, preferably analgesia, well beyond the limits of the tumor area, but also render insensitive, so far as possible, that part of the body to which pain is apt to spread. For the most part, section of the pain-conducting tracts in the spinal cord (chordotomy) answers these requirements.

For many years, following its introduction by Spiller and Martin (1) in 1912 and subsequent refinement by Frazier, chordotomy was applied only for relief of pain below the diaphragm—mainly in the pelvis and lower extremities. There remained unsolved the problem of pain in the chest, upper extremities, neck, and head, except for such procedures as posterior root section, which left much to be desired.

Stookey (2), in 1931, introduced high cervical chordotomy to raise the level of analgesia to include the upper chest and arm, mainly for the purpose of relieving pain resulting from carcinoma of the breast. In more recent years, other significant contributions have been made. Schwartz and O'Leary (3) and White (4), in 1941, reported sectioning of the spinothalamic tracts in the medulla to relieve pain as high as the neck and posterior scalp.

Schwartz and O'Leary's first patient died two days following operation, but in the meantime satisfactory neurological studies were possible. These revealed

[1] From the Department of Neurological Surgery, University of Virginia Medical School and Hospital. Presented at the Joint Meeting of the American Roentgen Ray Society and the Radiological Society of North America, Chicago, Ill., Sept. 24–29, 1944.

"almost complete analgesia and loss of 'tickling' sensation over the entire lower extremity, with preservation of touch. There was almost complete analgesia over the trunk to the level of the clavicle. There was hypalgesia over the arm and neck up to the left mandible." In another case recorded by Schwartz and O'Leary in which a similar procedure was employed, the patient was relieved of pain in the right chest, shoulder, and axilla, caused by inoperable carcinoma of the breast with metastases, until her death one month later.

White's patient was completely relieved of intractable unilateral neuralgia involving the arm, upper part of the chest, neck, and occiput, but unfortunately she was left with persistent cerebellar ataxia, probably due to injury to the restiform body. This complication, White believes, can be prevented by placing the incision lower in the medulla.

Dogliotti (5), in 1938, published an interesting and perhaps significant report on four cases in which he had sectioned the spinothalamic tracts in the mesencephalon, just above the incisura of the tentorium. His purpose was to make an incision high enough to block all pain impulses from the opposite side of the body, including especially those from the arm, neck, and cervicofacial region. One patient died thirty-six hours after operation. Commenting on the others, Dogliotti stated: "The three other patients all had uneventful postoperative recoveries. These patients during the first three to five postoperative days were quite restless and complained of diffused disagreeable sensations. The preoperative pains disappeared immediately in two patients with a complete secondary hemi-analgesia and were greatly reduced in the other patient."

Walker (6), in addition to duplicating Dogliotti's results, has been able to produce hemi-analgesia in either the upper or lower part of the body by differential section of the spinothalamic tracts in the mesencephalon. Neither mesencephalic nor intramedullary tractotomy has been performed bilaterally.

All of these procedures designed for the purpose of rendering large areas of the body insensitive to pain, and unavoidably thermo-anesthetic, by partial section of the spinal cord, medulla, or mesencephalon, are extremely useful, and each has its indication, depending on the level of analgesia required.

It is seldom that a patient having malignant tumor below the diaphragm e periences pain sufficiently high to dema anything more than an upper thoracic cho dotomy. Therefore, the higher section which are more difficult and more dange ous, should be employed only in tho cases requiring a high level of analgesi Upper thoracic chordotomy may be pe formed bilaterally without danger of di turbing vital functions. This is a decide advantage, as abdominal and pelvic pai rarely remains limited to one side. Sel dom, in cases of malignant disease, hav we limited the operation to one side. I fact, most of our patients have had spina metastases or other lesions requiring bi lateral chordotomy.

When cervical chordotomy is indicated it becomes necessary to bring the level of analgesia up to maximum height. This is not always possible, due, in part, to our incomplete understanding of the arrangement of various fibers in the spinothalamic tracts. In fact, the operation must be performed with perfection, and a certain amount of luck, to produce complete analgesia in the chest and upper extremities. It is understandable, therefore, why efforts are being made to develop operations at levels higher than the cervical region. While still in the experimental stage, both intramedullary and mesencephalic tractotomy seem to offer hope for uniformly good results in the upper part of the body.

We have performed cervical chordotomy only unilaterally. It is better to limit the operation to one side, as the incidence of respiratory paralysis is greater when both sides are done at the same time. Stookey (7), who has had considerable experience with this operation, suggests that in cases of bilateral pain operation on the second

de be postponed until after the patient as fully recovered from the first procedure.

ACTUAL AND POTENTIAL PENALTIES OF CHORDOTOMY

Retention of urine, particularly followg bilateral chordotomy, is to be expected. sually, however, normal bladder funcon returns within a few days to weeks. n some few cases, damage is permanent nd a serious urinary problem results. The ffect on sexual function is almost constant. jaculation is abolished, and, in the female, rgasm is lost.

The close proximity of the pyramidal racts to the spinothalamic tracts calls for recision in perfoming chordotomy. Forunately, paralysis of the extremities rarely ccurs; weakness, if any, usually is transiory.

A perfect chordotomy is exceptional, lthough satisfactory relief of pain is to be xpected in most cases. In an attempt to revent loss of motor function, one usually rrs on the side of incompleteness. Therere, it is sometimes necessary to reopen the ound and cut deeper into the cord. When ealing with permanently bedridden paents, one is inclined to be more radical nd show less regard for motor function. n this connection, I should like to emphaze the importance of adhering to the me standards of precision in all cases, for the pyramidal tracts are seriously inred, involuntary mass movements in the fected extremities may become soviont that the beneficial effect of chordotmy is greatly reduced.

During the past three years, 41 chorotomies have been performed on 35 patints by members of the visiting and resident aff of the University of Virginia Hospital. hirty-three were done on 27 patients with alignant tumors, and in this group there ere 2 hospital deaths, giving a 7.4 per cent ise and 6 per cent operative mortality. ne patient with carcinoma of the lung ith extension to the brachial plexus and eura died suddenly of respiratory paralys five hours following high unilateral cerval chordotomy. At autopsy nothing was discovered to account for the sudden death. The other patient, who had carcinoma of the pancreas, died of lobar pneumonia three days following bilateral upper thoracic chordotomy.

The mortality from chordotomy, as well as from other neurosurgical procedures for relief of intractable pain, is high but not unreasonably so, considering the unfavorable preoperative conditions that so many of these patients present.

RESULTS OF CHORDOTOMY

The results of chordotomy, particularly upper thoracic, are good. Failures occur, but usually these are due to incomplete section of the spinothalamic tracts. To obtain a better immediate result or to relieve recurrent pain in the area served by chordotomy, we have had to repeat the operation in 18.5 per cent of our cases. The incidence of secondary operations will diminish as we develop a better understanding of the anatomy of the spinal cord. Perfection, however, seems remote, as undoubtedly there do exist individual differences in the arrangement of fibers in the tracts.

THE USE OF ALCOHOL IN THE SPINAL SUBARACHNOID SPACE

The destruction of lumbar nerve roots by the simple method of introducing alcohol into the spinal subarachnoid space has not been widely accepted. As the placement of alcohol is not entirely controllable, the incidence of paralyses, particularly those involving the bladder and rectum, is high. Furthermore, when successful, the injection produces anesthesia in the lower part of the body, which favors the development of decubitus ulcers. Chordotomy is a much better procedure, and it is seldom that it cannot be substituted for the use of alcohol in this manner.

POSTERIOR RHIZOTOMY

Intraspinal section of sensory roots (posterior rhizotomy) is seldom employed except for relief of pain in the chest and neck. In these regions segmental inner-

vation favors the operation, and loss of sensation, in all forms, is not incapacitating. The magnitude of the operation, however, to render large surface areas anesthetic, makes it impracticable. Furthermore, division of numerous radicular vessels may cause serious ischemia of the spinal cord.

Posterior rhizotomy, by removing all forms of sensation, renders an extremity useless. This penalty would be acceptable in certain cases if relief of pain could be assured, but in the experience of many neurosurgeons, including the author, the results have been discouraging. At one time, posterior rhizotomy was extensively employed in an attempt to relieve pain in the swollen, often useless, arm due to carcinoma of the breast. Numerous failures, however, even after section of all sensory roots emerging from the brachial plexus, soon led to interest in the development of more promising procedures, such as high cervical chordotomy and tractotomy.

The pathways through which pain impulses from individual abdominal organs reach the spinal cord are fairly well understood, and these are known to include several posterior roots. Abdominal pain, especially when due to a malignant neoplasm, rarely remains limited to one organ, but spreads to contiguous structures. These may have either a higher or lower segmental innervation, which altogether involves so many nerve roots that relief of pain by rhizotomy is either impossible or impracticable.

SURGERY OF THE CRANIAL NERVES

Pain originating from tumors within the distribution of the trigeminal nerve, *i.e.*, tumors of the mandible, maxilla, tongue, lips, and paranasal sinuses, is completely relieved by the injection of alcohol into one or more branches of this nerve or by intracranial section of the sensory root. Even with moderate extension of the growth beyond this area, interruption of the trigeminal nerve together with the administration of analgesic drugs may be sufficient to insure reasonable comfort for several months. Numbness is the penalty, but this is gladly accepted in lieu of the constant agonizing pain which is so often associated with cancer of the face and mouth.

We have not been confronted with the difficult problem of relieving pain in both sides of the face and mouth. Academic as it may seem, it should be mentioned that both mandibular nerves should never be injected, as paralysis of the muscles of mastication would result. The motor root of the trigeminal nerve accompanies the mandibular branch through the foramen ovale and does not escape destruction when a deep alcohol injection is performed. It is well understood that the loss of one motor root is inconsequential. Relief of pain in both sides of the face and mouth with preservation of mastication is, of course, possible by section of the sensory root of both trigeminal nerves, but the resultant loss of sensation in all modalities would be intolerable.

Alcohol injection of peripheral branches or intracranial division of the sensory root of the trigeminal nerve on one side and section of the descending tract of the trigeminal nerve, as designed by Sjöquist (8), or preferably as modified by Grant (9), to reduce the incidence of hoarseness, on the other side, are logical procedures for the relief of bilateral pain. With sense of touch preserved in one side of the face and mouth, the penalty should not be much more unpleasant than that exacted by operation for unilateral tic douloureux.

Cancer of the face and mouth is well known for its chronicity. After a while, due either to progress of the disease itself or to cicatricial changes resulting from x-ray therapy, pain becomes so widespread that several nerves have to be interrupted in an attempt to bring relief.

Pain usually spreads from the trigeminal area to the posterior part of the tongue and pillars of the tonsils supplied by the glossopharyngeal nerve and to that part of the neck innervated by the upper three or four cervical roots. When confronted with this problem, we have in a few cases sectioned

all of these nerves in a one-stage operation as first proposed by Fay (10). The series is too small for a fair appraisal of the operation. However, encouragement is to be derived from the results in a comparatively large number of cases reported by Grant (11). This, or a similar procedure, employed in 49 cases, gave relief of pain in 80 per cent and partial relief in 12.5 per cent of his cases.

PREFRONTAL LOBOTOMY

One of the most important problems in connection with the management of cancer patients has received little attention from any source and none from the standpoint of surgery which actually possesses a solution. Reference is made to the patient's mental state. Regardless of how stoical a person may seem, he inevitably becomes depressed and anxious when faced with the stark reality of the hopelessness of his condition. To prevent or to relieve this mental state would be to render a service perhaps even greater than the relief of pain itself. Whatever may be the final decision concerning the value of prefrontal lobotomy, it cannot be denied that the operation abolishes worry and fear. Without these, cancer would be of little, if any, concern to its victims. It is predictable, therefore, that prefrontal lobotomy or a similar operation will assume an important role in the treatment of patients with incurable malignant disease.

CONCLUSIONS

The unsolved problems in connection with the transmission and relief of pain are numerous. With the aid of present-day surgical procedures, however, pain caused by known organic disease, such as cancer, can be relieved or greatly diminished in almost all cases. The risk is reasonable, and the penalty is more than acceptable by the unfortunate victim of a malignant tumor.

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DISCUSSION

(Papers by T. J. Wachowski and H. Chenault, Carleton B. Peirce et al., and W. G. Crutchfield)

Merrill C. Sosman, M.D. (Boston, Mass): The juxtaposition of the two papers [by Wachowski and Chenault and by Peirce and his colleagues] on the subject of irradiating brain tumors is indeed fortunate. One is struck, in reviewing the literature, by the high percentage of good or favorable results reported following irradiation. Only occasionally does one find a report of no benefit or actually harmful or deleterious results. The proportion is certainly two to one in favor of irradiation.

But here this afternoon the ratio is one to one. It takes a man like Dr. Bailey[1] to face the facts and assay them with a true investigative attitude of impartiality and to report them with his characteristic fearlessness before this audience. There is no doubt in my mind after this convincing demonstration but that roentgen irradiation delivered in the most approved manner has done extensive and permanent damage to the normal brain tissue. The

[1] Dr. Bailey was associated with Dr. Wachowski and Dr. Chenault in the authorship of their paper, though his name does not appear at its head.

nervous tissue was thought to be quite resistant to x-ray and radium treatments, and any damage which was found was attributed to the effect of irradiation on the small blood vessels and capillaries. Bailey, Wachowski, and Chenault have shown us that the reverse is true.

Dr. Peirce and his colleagues from Montreal have, on the other hand, given us definite and well documented evidence that probable prolongation of life and amelioration of symptoms have followed even larger doses of x-rays to primary tumors of the brain, and they have not observed any of the degenerative or vegetative effects described by Bailey *et al.*

What are we to conclude? Shall we accept these patients for treatment or not? And if we do, how can we best treat them to avoid the deleterious by-products of irradiation?

Analyzing these two papers, I can see only slight differences. Dr. Peirce starts with 100 r at each treatment and, if that is tolerated well, he raises it to 150 r a day to each of two ports, while Dr. Wachowski gives 300 r a day to a single port. Dr. Peirce uses a Thoraeus filter and Drs. Bailey, Wachowski, and Chenault have tried three machines, slightly different in voltage and in copper filter, but I do not believe the marked variation in results reported here is due to that slight difference in technic.

Speaking only for myself, I think we can conclude that a tumor dose anywhere in the brain, of 6,000 r or more, will cause definite damage to normal brain tissue, which may take months or years to reveal itself. But in the presence of an inoperable and irremovable tumor, such as the glioma, that risk is fully justified if amelioration of symptoms or prolongation of life can be expected, since we are dealing with an inevitably fatal disease.

Proceeding to generalizations, the same problem exists in all of our cancer therapy. With surgery becoming more expert and more complete, there are fewer and fewer curable cancers left for the radiologist. The striking exceptions are cancers of the skin, the larynx, and the uterine cervix.

If, then, we can do only palliative radiotherapy in the majority of the remaining cases, we must be sure that we do not make the patient worse in attempting an impossible cure of an incurable lesion. As far as I know, not one case of glioma has ever been cured by irradiation, but many have been improved by doses not exceeding 6,000 r in adults.

Most of you heard Dr. Camp's paper yesterday morning.[2] He told us what happens to the cranial bones twelve to fourteen years after irradiation with much smaller doses. His results were disquieting, to say the least, and each one of us must face the problem of possible late injuries from irradiation, particularly when treating more benign lesions than the gliomata under consideration here.

The same principle of analysis applies to Dr. Crutchfield's report on chordotomy and other surgical methods of relieving intractable pain, particularly in metastatic cancer. Do the end-results justify the time and trouble expended? Do harmful by-products occur often enough to outweigh the usual benefit?

All of us will agree that the results in selected cases of chordotomy or tractotomy do justify the operation and uphold our Hippocratic oath in a true humanitarianism. From the few cases of alcohol injection and posterior root section I have seen, however, those procedures do not seem to be justified by their incomplete or temporary results.

If we cannot cure, we can alleviate. If we cannot either cure or alleviate, then we are working in vain. Above all, we must avoid making these hopeless patients worse.

Vincent W. Archer, M.D. (Charlottesville, Va.): If a personal allusion may be pardoned, I may explain how I first became interested in the relief of pain in advanced cancer. A member of my family, years ago, had an extensive carcinoma of the base of the tongue, with resultant pain such as you are all familiar with. At that time nothing could be done except to use opiates, but though the dosage had been increased to huge proportions at the time of my relative's death, the pain could not be wholly controlled. Unfortunately he lingered on for about a year. So I have been personally much interested in doing something for these poor unfortunates.

The actual discussion of Dr. Crutchfield's paper is logically opened by reiterating his first sentence: "Rarely should a defeatist attitude toward intractable pain be entertained without an investigation of the possibilities of relief by means of surgery."

Where does the radiologist fit into this picture? He has been what may be called a road block on the path to the end that so many of these cancer patients envision. If the proper physician-patient relationship exists, the radiologist has the confidence of the patient. Therefore, when the pain grows unbearable, it is the radiologist whom the patient consults—the man who has treated him.

The radiologist naturally sees more cancer patients than any other one man among the group with whom he is working, because the majority of them come to him at some time. Therefore, he can get a pretty good idea of what goes on and what may be accomplished. He can do much toward promoting the proper use of neurosurgery in the relief of intractable pain in advanced cancer. There are, of course, certain painful lesions which can be treated more successfully by other methods. Each case must be evaluated individually. Patients with carcinoma of the prostate should certainly have the advantage of an orchiectomy. The relief of pain following this procedure is dramatic in many instances, while the melting away of hyperplastic new bone formation is familiar to all of us who have followed the results of the operation. Carcinoma of the breast that has metastasized to bone, with very painful

[2] See page 213.

areas, should unquestionably receive radiation therapy because of the striking response so often obtained, with relief of pain and even bone regeneration. The same is true of many other far advanced malignant growths. Each case must be individualized. Just because the patient has pain does not mean that he is a candidate for neurosurgery.

For patients who are not amenable to radiation or other less drastic forms of treatment than neurosurgery, the latter procedure should be considered. The general surgeon or radiologist should not take it upon himself to pick and choose the cases that should have this type of treatment. He should have the advice of a competent neurosurgeon.

Though Dr. Crutchfield did not make the statement in his paper, he has said that he is afraid he appeared a bit too pessimistic. I take issue with him on this point, for he is adopting the surgeon's point of view that if you fail to get a complete cure the operation has not been successful. On the other hand, if you can reduce a grade 4 pain to a grade 1 pain, you make life far easier for the patient.

Dr. Crutchfield spoke about the untoward byproducts of neurosurgery—the loss of sphincteric control and the paralysis of the extremities that sometimes occurs. When you see these patients writhing with pain, except for the shortening intervals when they are under narcotics, and then see them lying fairly comfortably in bed, even with a lack of sphincteric control, you feel that they have made a pretty good swap. Their expected span of life is not long and, even with such so-called bad results, relief for six weeks or two months makes the last mile a bit more tolerable.

I think that Dr. Crutchfield has done a lot for the patients on whom he has operated in our clinic in this matter of pain relief. I do not believe that the mortality incident to neurosurgical procedures thus used should enter into the picture at all, for the patients are already near the end.

Percival Bailey, M.D. (Chicago, Ill): I do not agree with Dr. Sosman that the score this afternoon regarding x-ray treatment of brain tumors is one to one. I did not say that x-ray treatment of brain tumors does not produce improvement, nor do I believe it. In all of the cases that we showed this afternoon, very definite improvement followed x-ray treatment—in one instance for as long as six years before the inevitable decline set in. X-ray treatment *does* produce improvement in cases of brain tumor. I am quite convinced of that. But I am also thoroughly convinced that you can't get any better results with 15,000 r than you can with 5,000 r and that you may produce irreparable damage to the brain.

It is difficult to discuss critically a paper like that of Dr. Peirce without having all the data at hand. Merely looking at figures doesn't get one very far. I am not convinced that any of his patients with medulloblastoma had their length of life increased beyond that which could be obtained by 5,000 r, nor am I convinced at all by his figures that his astrocytoma patients had their lives prolonged even by treatment with 15,000 r. The astrocytoma is a very long-lived tumor. I have known patients to live fifteen or twenty years postoperatively.

Now to produce a degeneration of the brain in trying to cure glioblastoma multiforme may be justifiable. When you see a big glioblastoma that you know is going to kill the patient in a few months and realize that there is no other hope for him, you can give him as much x-ray radiation as his skin and underlying tissues will tolerate; prevent him from getting a big, unsightly hernia, and produce a frontal lobotomy without having to resort to surgery. I have done that intentionally. You destroy the frontal lobes of the brain and the patients do not worry, they do not have any fear, do not have big unsightly hernias, and do not suffer from headache. Altogether it's a good thing, in such cases, to produce a degeneration of the brain.

An astrocytoma, however, is an entirely different matter. I do not believe it is justifiable to give 15,000 r in such cases and risk producing a degeneration of the brain which may not come on for at least six years after cessation of the treatment.

Dr. Peirce states that in none of his cases was a degeneration of the brain provoked. It is impossible for me to judge the accuracy of that statement without all the clinical records available for study. On the basis of my own experience I believe it to be very probably incorrect.

Commander C. B. Peirce (*closing*): Dr. Bailey, of course, is maintaining a very consistent attitude. We accept his challenge.

I would call attention to the fact that of the four cases which have been analyzed histologically by him, the average length of life was fifteen months. For our patients who are now dead, average duration of life was 14.3 months for those with glioblastoma and 17 months for those with astrocytoma. There is a definite loss ratio in the glioblastoma and the astrocytoma group, no matter what is done, with surgery, with irradiation, or with neither.

It is our feeling that the case is not closed; that it warrants further study.

Further, on the basis of our experience, we feel definitely that more conservative initial irradiation is advisable. In that regard, too, I would call attention to the fact that in irradiation of any lesion we must avoid damage to surrounding and overlying normal tissue to the maximum degree, save in so far as is necessary to produce an effect on the tumor.

Consequently, my feeling is that higher filtration, fractionation within moderate limits so as to confine the complete course within forty-two to forty-nine days, and the avoidance of large fields or any more fields than are necessary for adequate irradiation of the tumor and its environment, are advisable.

The Roentgen Appearance of Lobar and Segmental Collapse of the Lung

V. Collapse of the Right Middle Lobe[1]

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COLLAPSE OF THE right middle lobe of the lung occurs frequently, and is still confused with interlobar effusion (1). The location of the middle lobe, between the greater and the lesser fissures of the right lung, explains the original mistaken roentgenologic interpretation of these two processes. On the roentgenogram, the pulmonary fissures appearing as lines, or septa (4, II), are now recognized as boundaries of the various lobes. The minor septum and approximately the lower half of the right major septum bound the middle lobe. In collapse of this lobe the septa tend to come closer together as the lobe decreases in size, and the final shadow of increased density may simulate that of interlobar effusion which would, if present, lie in the same plane. The shape of the shadow cast by interlobar effusion, however, is different, and very rarely is a proved case seen without fluid elsewhere in the pleural cavity. At the present time, the diagnosis of collapse of the middle lobe can be made accurately if certain definite characteristic signs are looked for, and if their importance is recognized.

Collapse of the right middle lobe, or of one of its segments, occurred in 26 per cent of the group of 600 cases of collapse studied. It is our purpose to discuss in detail the roentgenologic appearance of the pulmonary abnormalities which distinguish collapse of the middle lobe, or of its segments, and the most satisfactory means of demonstrating them.

The middle lobe lies in the antero-inferior portion of the right chest, making up essentially all of the pulmonary tissue adjoining the right border of the heart as seen on the roentgenogram. It is demarcated by two septa, the minor running more or less horizontally and the major running downward and anteriorly, as previously described (4, II). The bronchus to the right middle lobe arises from the right main bronchus at the level of the origin of the bronchus to the dorsal division of the right lower lobe. The middle lobe bronchus immediately divides into two branches, the anteromedial, which supplies the segment of the lobe adjoining the right border of the heart, and the posterolateral, which supplies the segment lying adjacent to the upper lobe and the anterolateral chest wall.

Complete obstruction of the bronchus to the right middle lobe causes the lobe to decrease markedly in size, and roentgenologically to assume a somewhat pyramidal shape with its base against the right border of the heart and its apex extending toward the lateral chest wall. Since the general plane of the middle lobe is more or less oblique, running from the hilus anteriorly and inferiorly to the lower fourth of the anterior chest wall, the ordinary postero-anterior roentgenogram does not catch it entirely in profile, and thus the fact that it is the site of a disease process may not become apparent until some other abnormality is observed—that is, loss of definition of the right border of the heart. Since almost all of the lung immediately adjacent to the right border of the heart consists of right middle lobe, any interference with its aeration will produce loss in definition of this border. This is true both of atelectasis and of collapse due to obstruction caused by a foreign body or tumor, or to pneumonic consolidation.

Another factor which somewhat obscures the actual condition of the middle lobe

[1] From the Department of Radiology, Massachusetts General Hospital, Boston, 14. One of a series of pa[pers] accepted for publication in October 1944.

Fig. 1. Collapse of the entire right middle lobe. A. The shadow of increased density represents the col-psed lobe, which obscures the right border of the heart. B. The *Kreutzhohlstellung* projection more clearly efines the collapsed lobe. See also Figure 1C.

n the postero-anterior roentgenogram is hat at least two-thirds of the inferior por-ion of the right chest is occupied by the ower lobe. Normal aeration of the lower obe, therefore, permits fairly good radi-nce of the lower lung field even in the resence of atelectasis or collapse of the niddle lobe.

The importance of the lateral roentgeno-ram in all forms of collapse has been tressed previously; in examination of the ight middle lobe, it is the most essential ingle factor in the examination (3). In his projection, the middle lobe, when en-irely collapsed, is represented by a band of ncreased density, varying in thickness from everal millimeters to 2 or 3 cm., located n the plane of the antero-inferior portion f the major septum. The widest portion f the shadow always lies against the an-erior chest wall or the diaphragm. The pper portion of the shadow diminishes n width until it forms an apex at the junc-ion of the major and minor septa. The hadow of collapse is frequently interpreted s a collection of fluid or exudate, since it ives the impression that it follows the lane of the greater fissure. Actually it can e differentiated from interlobar effusion

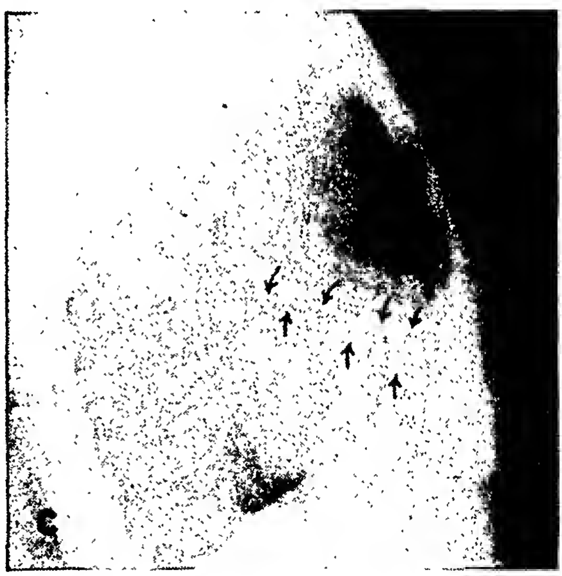


Fig. 1C. Collapse of the entire right middle lobe. The arrows indicate the margin of the collapsed lobe. The dense white line represents its lateral portion as it is superimposed on the bulk of the middle lobe shadow. Bronchoscopy showed the middle lobe orifice to be narrowed and completely blocked by thick secretion. Bronchiectasis of the collapsed right middle lobe was demonstrated by bronchography.

by the shape of the shadow of increased density. In the case of collapse of the middle lobe, this shadow is somewhat tri-angular and includes the shadows of the major and minor septa; in interlobar ef-

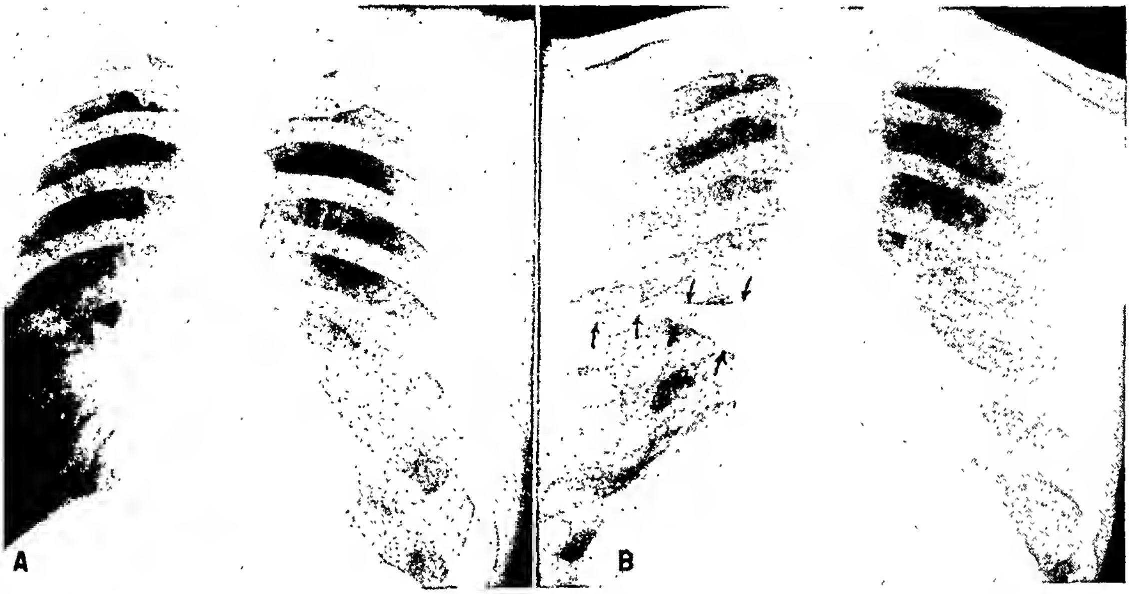
Fig. 2. Partial collapse of the entire right middle lobe. The middle lobe is only moderately decreased in size. The shadow of increased density is larger than that usually seen because the amount of collapse is not great. Shadows similar to this are sometimes confused with those due to interlobar effusion.
Right middle lobectomy. At operation the middle lobe was found to be collapsed and indurated.
Histopathology: Bronchiectatic abscess: acute and chronic pneumonitis.

fusion it is ovoid or elliptical and at least portions of the septa will usually be visible and in normal position.

The definition of the shadow of increased density caused by collapse of the middle lobe can generally be enhanced by use of the lordotic position (Kreutzhohlstellung) (2). In this view, it stands out because the greater portion of the lobe is more nearly parallel to the central ray and the bulk of the lobe is shown in profile. Observation of the middle lobe in this projection is easily accomplished during routine fluoroscopy and should be made more frequently.

The hilus is seldom, if ever, depressed as the direct result of collapse of the right middle lobe. The antero-inferior portions of both the upper and lower lobes tend to come together as the middle lobe contracts and thus occupy the space formerly filled by it. Since normally the middle lobe fills a relatively smaller portion of the chest than the other lobes, no striking emphysema is demonstrable as a rule, nor are the heart and mediastinum often displaced appreciably to the right. Since almost all of the diaphragm is outlined by the aerated lower lobe, collapse of the middle lobe does not usually interfere with its demonstration.

Segmental collapse of the right middle lobe was seen more frequently than complete collapse. The lobe has two main segments, the anteromedial and the posterolateral. The former is more often involved in collapse than the latter. Collapse of the anteromedial segment is difficult to differentiate from collapse of the entire lobe, since in both instances the outline of the right border of the heart is at least partially obscured. Only by careful scrutiny of the shape and location of the shadow of increased density, and the observation that the minor septum is still demonstrable in a relatively normal position, can it be determined that collapse is confined to the anteromedial segment. In the postero-anterior roentgenogram the shadow of increased density appears directly in apposition with the right heart



ʼig. 3. Collapse of the anteromedial segment of the right middle lobe. A. A collapsed anteromedial segment ·duces a shadow of increased density which obscures the right border of the heart. The arrow indicates the ible portion of the minor septum adjacent to the aerated posterolateral segment of the middle lobe. B. The *ɛnɛhohlstellung* projection shows that the shadow of density does not extend to the lateral chest wall as in col-se of an entire middle lobe. The lateral portion of the minor septum is visible. See also Figure 3C.

rder and does not extend laterally as ·as that of the entire lobe. In the lateral ɔjection, the shadow tends to lie more teriorly and inferiorly than in collapse of ɛ entire lobe (Fig. 3). If, on the other nd, the posterolateral segment only is ʼolved, the definition of the right border the heart, in the postero-anterior roent-nogram, will remain sharply defined, the area of density is located farther ·erally. In the lateral view, the shadow increased density is in the posterior por-ʼn of the area ordinarily occupied by the ddle lobe. The portions of the major d minor septa adjacent to this shadow ɛ lost, but the remaining portions are ·arly visible, indicating that the antero-ɛdial segment is aerated (Fig. 4).

Collapse of the right middle lobe asso-ıted with collapse of the right lower lobe, ıe to bronchial obstruction, may be dif-ult to identify, as the combined shadow increased density is quite characteristic collapse of a lower lobe alone. A dif-rential feature, however, is that in col-pse of the two lobes it will be impossible ı any roentgen projection to demonstrate ·e minor septum.

Fig. 3C. Collapse of the anteromedial segment of the right middle lobe. The arrows indicate the location and shape of the collapsed anteromedial segment. Bronchoscopy did not reveal the cause of collapse.

Although this discussion has dealt primarily with the right middle lobe, in general what has been said applies to a great extent to collapse of the lingula on the left. In position, the right middle lobe and the

Fig. 4. Collapse of the posterolateral segment of the right middle lobe. In the postero-anterior projection, the right border of the heart is sharply defined but the shadow of inereased density is barely recognizable. In the lateral view, the shadow of density, outlined by arrows, represents the collapsed posterolateral segment. There is ineidental eollapse of the dorsal division of the lower lobe. Bronehoseopy failed to reveal the cause of collapse.

Fig. 5. Collapse of the lingula of the left upper lobe. In the postero-anterior projeetion the shadow of increased density is outlined by arrows. It is slightly higher than is usually seen in eollapse of the entire lingula, but it obseures a portion of the left heart border. In the lateral view, the shadow of density lies in the anterior portion of the ehest, superimposed upon the upper part of the heart shadow. The position of the major septum of each lung is elearly demonstrated.

Left upper lobectomy. Grossly the speeimen showed eollapse of the lingula and some involvement of the axillary segment.

Histopathology: Epidermoid eareinoma, grade II.

Fig. 6. Collapse of the anterolateral segment of the lingula of the left upper lobe. In the postero-anterior projection the shadow of increased density lies laterally and the left border of the heart is sharply defined. In the lateral view, the shadow of density is seen in the position usually occupied by the anterolateral segment of the lingula (arrows). The posterior margin of the shadow indicates the position of the major septum of the left lung. The asterisk indicates the position of the major septum of the right lung.

lingula of the left upper lobe are analogous. Anatomically, they differ in that the one is a separate lobe and the other is not, and in the origin and distribution of their bronchial supply. The lingular bronchus arises from the proximal portion of the left upper lobe bronchus and divides into two branches supplying the anterolateral and the posteromedial segments of the lingula. Bronchiectasis often causes collapse in the lingula of the left upper lobe associated with similar involvement in the lower lobe, but it is not readily recognized without bronchography. This is due to the fact that the collapsed lingula moves posteriorly and becomes confluent with the shadow of the collapsed lower lobe.

Approximately 20 cases in our series have been interpreted as isolated collapse of the lingula, but in general they are insufficiently proved to make detailed description of their roentgen appearance worth while. Briefly, in the lateral roentgenogram, the shadow of collapse of the lingula is much like that of the right middle lobe. It lies in much the same location and its configuration is similar. In the postero-anterior view, it lies close to the heart and tends to obliterate or blur the left border (Fig. 5).

A certain number of cases in which segmental collapse of the lingula was believed to be present have been seen. This is not as easily identified as segmental collapse of the right middle lobe because of the absence of a minor septum on the left side. The anterolateral segment has been more often involved than the posteromedial. In the postero-anterior roentgenogram, the shadow of a collapsed anterolateral segment lies close to the lateral chest wall and does not obliterate the left border of the heart; in the lateral projection, it lies against the septum (Fig. 6). A few cases have been seen in which the posteromedial segment was believed to be collapsed, and in them the shadow of increased density was similar to that caused by collapse of the entire lingula, except that it was smaller and its lateral portion was aerated.

CONCLUSIONS

Collapse of the right middle lobe should not be confused with interlobar effusion.

Collapse of the middle lobe is recognized by the size, shape, and location of the shadow of increased density, which usually obscures the right border of the heart.

Collapse of the lingula of the left upper lobe is similar to collapse of the right middle lobe in certain respects.

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Intestinal Obstruction: Further Experiences in the Use of Flat Abdominal Films[1]

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IN 1937 WE REPORTED a series of cases of intestinal obstruction diagnosed with the aid of flat films of the abdomen. The experience gained in the first series proved of considerable value in estimating the significance of a distended abdomen, and we have continued our study for the past seven years. While we have nothing startling to report, we feel that certain impressions and experiences should be recorded.

Perhaps a few statements should be made as to the findings which enable one to make a diagnosis of mechanical obstruction by the use of flat films. A gas bubble is normally present in the stomach, and gas in varying amounts in the colon. The small bowel, on the other hand, shows little or no gas when normal peristaltic movements are present. In the presence of abnormal stasis, however, gas begins to collect proximal to the point of stasis and quickly becomes visible on the roentgen film. Gas in the colon normally is derived from small bowel contents. When these contents fail to reach the large bowel in sufficient amounts, the colon gas is diminished and in severe cases disappears. These are the physiological facts upon which is based the roentgenographic diagnosis of obstruction. The roentgenologist, therefore, when confronted by a film, must determine:

(1) Is there gas in the intestinal tract?
(2) Is it in the colon or in the small bowel or both?
(3) If in both, what is the relative amount in each?

With these three questions answered, a diagnosis can readily be made and a shrewd guess can be hazarded as to the location of the obstruction.

The real problem lies in the second question, as the utmost care may at times be necessary to differentiate between small and large bowel. Since this differentiation is all-important for a diagnosis, considerable effort and study should be devoted to its accomplishment. We have found that a repeat examination, sometimes within an hour, is the greatest single aid in solving this problem. Certainly, we must admit, cases are encountered in which it is extremely difficult to distinguish between the distended Kerkring folds of the small bowel and the normal haustral markings of the large bowel.

Occasionally one is satisfied that gas is present in both the small and large bowel. This could be due to a reflex paralytic ileus from shock, as from renal colic, to gastrointestinal pneumatosis, peritonitis, or partial mechanical intestinal obstruction. If treatment is to be instituted at a favorable time, differentiation of these conditions is of prime importance. It can be made only after careful study and repeated examinations. One must determine whether the small bowel is distended more than the large bowel. If both are equally distended (not necessarily to the same size; it is a question of percentages), paralytic ileus is considered first. If the small bowel attains the size of the colon in the film, partial mechanical obstruction is diagnosed. The whole problem resolves itself into a comparison of the size of the gas collections in the small and large bowel, keeping in mind the normal size of each. We have always felt a little uneasy as to our diagnostic criteria in cases where enemas had been given recently. It seemed logical to suppose that an enema could remove the gas from the colon in a case of peritonitis or paralytic ileus and thus lead to a diagnosis

[1] Read by title at the Twenty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 1–2, 1943.

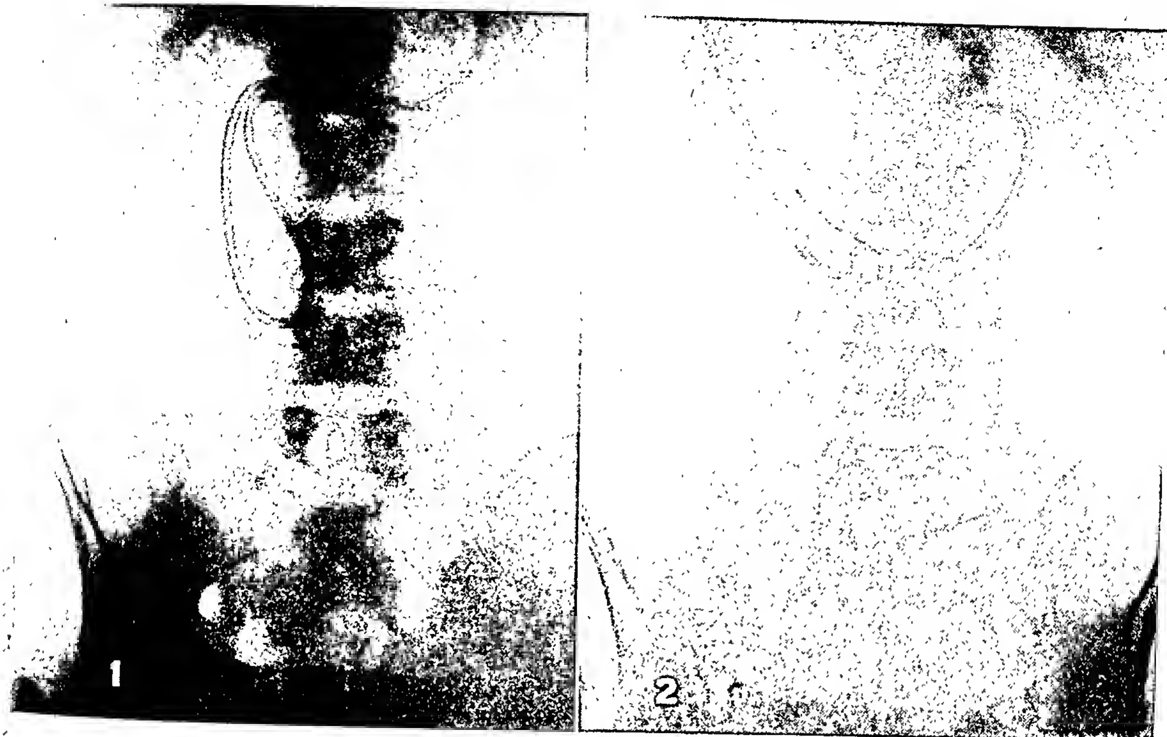
of mechanical obstruction of the small bowel based on the presence of small bowel gas, which is always present in paralytic ileus. We are now convinced that an enema does not remove the gas from the ascending colon in the presence of paralytic ileus, so that an erroneous diagnosis of small bowel obstruction need not be made. The gas in the cecum and ascending colon is enough to rule out such a diagnosis.

With the introduction of the Miller-Abbott tube and Wangensteen decompression, there followed a radical change in the attitude of the physician toward mechanical intestinal obstruction. Many surgeons and internists have come to regard intestinal obstruction as no longer an emergency. Too frequently the instruction is given: "Just pass the Miller-Abbott tube and we'll study that patient again in the morning." Our experience does not justify this attitude. Several of the fatal results in the present series of cases could be attributed directly to the use of the Miller-Abbott tube, that is to say to its *abuse*, not its correct use. Time and again the Miller-Abbott tube is confidently passed by an intern, only to have the x-ray on the following morning show it in the stomach, or at most in the duodenum. The internist—and many times the surgeon—will then make a strenuous effort to pass the tube further along and will order another x-ray study the next day. This time, the tube is perhaps found a little further on, or it may be merely curled up in the stomach. Frequently the stomach and the upper jejunum have been relieved during this forty-eight-hour test period, but the obstruction is still present and the coils of the distal bowel are still distended. Actually, because the proximal gas has been relieved, the abdomen may show slightly less distention and the patient may feel a little better. Thus another day may be taken up with inadequate drainage, and an operation is finally attempted, at the insistence of the x-ray department, only after a lapse of seventy-two hours. It is this type of case that has raised the mortality figures in our present series. At the end of seventy-two hours of improper drainage, gangrene of the bowel is not infrequently found, with the usual disastrous result. We know that it is entirely unfair to judge the Miller-Abbott tube on the basis of such cases, but in our experience the patient has fared better with early operation—as soon as the diagnosis of obstruction was made—than with the ineffective use of tube drainage and observation. We feel that the general surgeon, without special training in the use of the tube, is likely to abuse this method of treatment to the detriment of the patient. Our present series numbers 65 cases. We have chosen a few representative ones to illustrate some of the problems in the care of intestinal obstruction. The first is the type of case which we call "Miller-Abbott tube neglect."

CASE I (Figs. 1 and 2): The patient was admitted to the hospital on March 4, 1944, complaining of cramp-like pains in the abdomen for the past three days. For one week preceding admission, she had had an acute vaginal discharge associated with pain in the lower abdomen. An appendectomy had been performed seven years previously.

The patient was acutely ill. The abdomen was rigid and moderately distended, and there was tenderness in both lower quadrants. A diagnosis of gonococcal salpingitis was made by the clinician. For the next six days the patient was treated conservatively for pelvic peritonitis. Surgical consultants concurred in this diagnosis, and operation was considered unnecessary and undesirable at this time.

The x-ray examination was done six days after admission. Flat films were first made, leading to a diagnosis of mechanical obstruction of the small bowel, based on small bowel distention and lack of gas in the colon. A Miller-Abbott tube was then passed for the first time, and conservative treatment started in deference to the x-ray report. The surgeon, however, was not convinced and still considered peritonitis the more likely diagnosis. There was slight improvement, and on further surgical consultations, operation was deemed unnecessary. The next day another x-ray examination was made, again leading to a diagnosis of intestinal obstruction. The findings, however, were not completely conclusive, so that after three hours examination was repeated. This time intestinal obstruction was diagnosed without qualification. We considered obstruction complete and urged immediate surgery in spite of the apparent slight improvement in the patient's condition. Surgery was not considered necessary by the clinician, however, and twenty-four



Figs. 1 and 2. Case I. In Figure 1 the Miller-Abbott tube is in place but has not left the stomach. There is some small bowel distention resulting from intestinal obstruction. Figure 2 shows the tube still in the stomach on the next day. The small bowel distention is worse. The surgeon was still not convinced.

hours later a further x-ray examination showed complete obstruction.

The surgeon, finally persuaded to operate, found complete obstruction of the small bowel with multiple perforations and gangrene. A resection was done. Convalescence was stormy but, with the aid of sulfa drugs, the patient recovered.

Comment: The diagnosis in this case was clouded by the clinical picture of acute salpingitis. The Miller-Abbott tube apparently stopped the vomiting, giving a false impression of improvement. The surgeon, though well trained, was not fully aware of the value of flat films in such a case and delayed operation for a whole week. We have learned to regard x-ray examination in such cases as a very important procedure for determining the need for surgery. In this connection, it should be noted that, despite the slight improvement in the patient's general condition at one time, the nurse consistently reported "no gas" returning from the rectal tube. Stethoscopic examination of the abdomen also was inconclusive, so that, while we recommend such examinations, we have not found them very trustworthy. Another significant finding in this case was that, in spite of the many days of use, the Miller-Abbott tube never passed beyond the duodenal curve. Use of the tube made for a feeling of false security and led astray the clinician as well as the surgeon.

A second type of case which deserves some comment is "postoperative convalescent obstruction." We do not have in mind here the distention and distress occurring several days or so after what appears to be an uneventful postoperative convalescence. Such a case is under immediate suspicion for mechanical obstruction. We have reference particularly to the patient who has had a fairly stormy course for three days, with evidence of peritonitis, and then feels better, only to show distention again about the tenth day. Frequently there is no appreciable recovery from the initial peritoneal irritation, but distention appears almost continuous from the first day. This case is the one that so frequently has been diagnosed as peritoni-

Fig. 3. Case II. Postoperative convalescent obstruction. The tube is coiled in the stomach. Small bowel distention indicates mechanical obstruction. The surgeon refused to recognize the necessity for further operative procedure and the patient expired during an operation which was undertaken too late.

tis and paralytic ileus. The condition may be neglected for days unless tube drainage is successful in holding the distention in check. Time and again we have pleaded with the surgeon for proper x-ray examination, and time and again the answer has been: "What's the use? The portable film is unsatisfactory and the patient is too sick to be moved. Besides, we have already passed the Miller-Abbott tube. Let's wait; what can the x-ray do for peritonitis?" While we are quite aware that tube drainage may be of tremendous value in just this type of case, it has rarely been successful in our hands. We repeat that this is not the fault of the tube. We feel it is our inability to pass it properly and quickly. It is not unlikely that this is the experience in many other general hospitals.

Quite aside from the use or abuse of the Miller-Abbott tube in this type of case, there is still another obstacle that the ordinary surgeon has been unable to overcome; that is the problem of moving the sick patient to the x-ray department for an adequate x-ray examination. Some of these patients are not suffering from paralytic ileus. Their distention is due to a mechanical obstruction. Operation is essential. If a diagnosis is not too long delayed, cure is easy and mortality is practically nil. We believe that moving the patient to the Bucky table is no real hardship, that it is without danger and will frequently reward the surgeon with a quick, accurate diagnosis as to the type of distention which is present. We can see no harm in lifting the patient carefully onto a cart and then onto the x-ray table. In this connection, it must be mentioned that occasionally the stationary Lysholm grid has given us portable films adequate for a diagnosis. A typical case of postoperative convalescent obstruction follows:

Case II (Fig. 3): The patient was admitted to the hospital on May 25, 1941, complaining of abdominal cramps accompanied by menstrual disturbances and a vaginal discharge. A diagnosis of bilateral salpingitis was made, and twenty-four hours later a laparotomy was performed. Both tubes, the fundus of the uterus, and the left ovary were removed, together with the appendix. The convalescence was a little stormy, and four days after operation the patient began to show some distention. In an effort to relieve this, a Levine tube was passed. At this time, a diagnosis of peritonitis was made.

On the eighth postoperative day, an x-ray examination was finally made, and a diagnosis of mechanical obstruction of the small bowel was reported. The tube was shown to be in the stomach. A second examination was made one hour later, again indicating mechanical obstruction, and operation was urged. The attending physician still could not be aroused. Surgical consultation was called the following day, and a diagnosis of mechanical obstruction with peritonitis as a result of rupture was made. The surgeon advised immediate operation. A perforated bowel was found, markedly distended as a result of a mechanical obstruction. An ileostomy was done, but the patient died the same day.

Comment: Here is a case of a mechanical obstruction developing in the postoperative convalescent period, with treatment for peritonitis for eight days before an x-ray examination was even ordered. In addition, the operation was delayed twenty-four hours after an x-ray diagnosis was made, because the surgeon was not convinced that mechanical obstruction was present. We feel reasonably certain that if an x-ray examination had been ordered

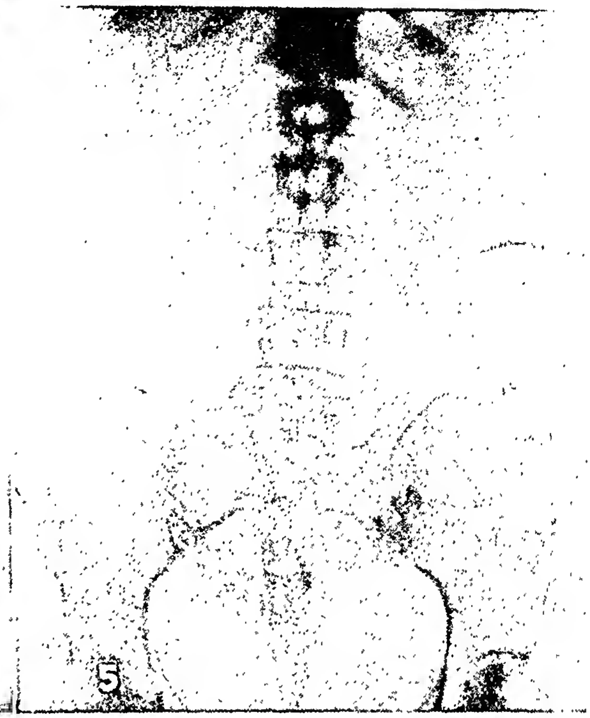



Fig. 4. Case III. "No gas" intestinal obstruction. Abdomen flat in this case, probably because of the high obstruction found at operation. Immediate relief following surgery.

Fig. 5. Case IV. The pre-x-ray diagnosis was urinary colic. X-ray showed no stones. There were minimal amounts of gas in the small bowel and none in the large bowel. A diagnosis of intestinal obstruction was made with some hesitation. Further clinical examination showed a small incarcerated femoral hernia. Operation brought about immediate relief.

on the fifth day, as soon as distention was observed, a diagnosis of mechanical obstruction followed by operation would have saved this patient's life.

Perhaps the most intriguing case that has come to our attention is the one we call the "no gas" obstruction case. Here we have reference to the film which shows no gas in the colon and practically none in the small bowel; at least, the small bowel gas is well hidden and seen only on very close inspection. Absence of gas in the colon immediately puts a case under suspicion of mechanical small bowel obstruction. This is logical, on the theory that colon gas is derived from the small intestine contents. This, however, is only half of the story. For a conclusive diagnosis, at least in the past, we have demanded the presence of small bowel gas in addition to diminution or absence of gas in the large bowel. Such cases are relatively easy to diagnose. When the small bowel distention is not seen, one is inclined to interpret the findings as normal. The absence of colon gas is then accounted for by supposed rigorous and successful cleansing enemas and physics. This group of findings has been a source of considerable anxiety to us. Frequently we have been forced to go into the clinical history for aid. It is helpful to know (1) whether there have been many successful enemas and the type of return; (2) whether bowel movements have occurred; (3) whether intestinal obstruction is suspected.

Cases III, IV, and V are examples of "no gas" intestinal obstruction.

CASE III (Fig. 4): The patient was admitted for the first time on May 28, 1942, complaining of pain in the abdomen and bloating. She vomited several times and the bowels would not move without an enema. She was nauseated and could not eat or drink. This condition had been present for forty-eight hours. There was a history of cesarean section four years before and a hysterectomy two years later. Physical examination showed two operative scars and a relatively flat, soft abdomen with tenderness

in the lower left quadrant. The patient remained in the hospital two days and was discharged as improved, with a diagnosis of fecal impaction. No films were taken at this first admission.

The next day the patient returned, feeling worse. At this time films of the abdomen showed no appreciable gas in the small or large bowel. This absence of colon gas, in spite of the lack of visible small bowel distention, was considered significant, and a diagnosis of mechanical obstruction in the small bowel was made. At operation a band of adhesions was found, completely obstructing the jejunum. The colon was collapsed, as was a good portion of the ileum. Recovery was uneventful.

Comment: Fortunately a resection was not necessary in this case. If films had been made at the first admission, several days of obstruction might have been eliminated. The relatively flat abdomen was probably due to the high obstruction.

CASE IV (Fig. 5): The patient was admitted July 24, 1943, and discharged Aug. 2, 1943. The complaint was severe pain in the abdomen; no vomiting. There had been no previous surgery. The bowels had always been regular until the present illness, which was of only forty-eight hours' duration.

Examination showed a good general appearance, dry tongue, and distended rigid abdomen. Tenderness was present over all the abdomen. The attending physician suspected renal colic, but an x-ray film of the urinary tract showed no stones. There was practically no gas in the colon, and very small collections of gas were scattered through the small bowel. A diagnosis of mechanical obstruction in the ileum was made. In the absence of a previous history of operation, we urged the attending physician to look again for a hernia. A small incarcerated femoral hernia was then discovered. Operation showed marked dilatation of the small bowel up to the incarcerated loop in the hernia. The patient made a good recovery.

Comment: Here again the absence of gas in the colon pointed to the correct diagnosis even though the condition had been missed by the attending physician. In these cases it must be stated that, unless obstruction is previously suspected, the film is likely not to arouse suspicion. Actually the diagnosis of obstruction in this instance was not made immediately by the x-ray department. It was made only on the next day, and then with considerable hesitation. Every once in a while a film of the urinary tract is encountered showing little or no gas in the colon. It would be entirely impractical to diagnose mechanical obstruction in all such cases. Clinical symptoms must be checked, and progress films must prove the lack of gas to be constant. It is likely that some patients may normally have only small amounts of gas in the colon. It is also possible that the patient may have been examined just after a good bowel movement, or several successful enemas may have been given. All these factors must be determined before a diagnosis of mechanical obstruction can be based on "no gas" in the bowel. Seldom, however, have we been able to influence appreciably the amount of gas in the ascending colon by ordinary enema.

CASE V (Fig. 6): The patient was admitted Jan. 14, 1941, and discharged Feb. 1, 1941. For the previous two days, she had been complaining of abdominal cramps and repeated vomiting. The past history showed an appendectomy.

The patient was acutely ill and in great pain. The abdomen was soft and not distended. A diagnosis of food poisoning was made. Medical consultation the next day suggested acute pancreatitis. Transfusion was ordered. X-ray examination was done at this time to rule out obstruction. Films taken thirty hours after admission showed no colon gas and small amounts (negligible, as in the usual abdominal examination) in the small bowel. An x-ray diagnosis of small bowel mechanical obstruction was made, but the attending clinician was not convinced.

At surgical consultation, two days later, mechanical obstruction was first considered, and then paralytic ileus. All this time the Levine tube had been in place. An operation was finally done on the third day, and intestinal obstruction was found. A large segment of the ileum was hemorrhagic. There was much bloody fluid in the peritoneal cavity. A dense adhesion was cut. No resection was necessary. The patient recovered nicely.

Comment: The absence of gas in the films (Fig. 6) was striking, but the clinician could not be convinced in view of the lack of abdominal distention on admission. Much of the diffuse shadow in the abdomen is probably due to the bloody fluid in the peritoneal cavity, but this fluid could not obstruct a view of gas collections if they had been appreciable. Could fluid within the distended loops obscure the gas shadow in the films? In our previous series of intestinal obstruction, we showed that large amounts of fluid in the small bowel

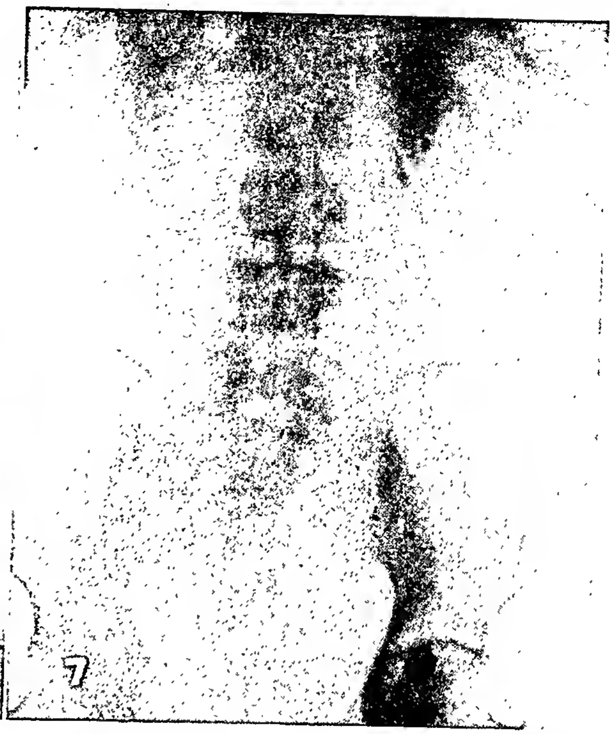


Fig. 6. Case V. "No gas" in abdomen. No x-ray examination for first thirty hours. Clinical diagnosis was food poisoning. Surgery delayed for two days even after x-ray diagnosis of obstruction. At operation, a band of adhesions was cut successfully. The fluid in and around the coils in the intestines may be the cause of the x-ray finding of "no gas."

Fig. 7. Case VI. History of previous ulcer led the clinician to make a diagnosis of impending rupture of ulcer. No x-ray examination for three days. The film shows a "no gas" intestinal obstruction. Operation performed immediately after x-ray diagnosis. The patient expired, delay in x-ray examination being an important contributing factor.

can, under certain conditions, completely obscure the gas in the distended bowel.

Although this group of cases is called "no gas" obstruction, the classification is not literal. At first glance there appears to be little or no gas; on close inspection a single distended loop of small bowel is usually seen.

Many clinicians at our hospital are fully aware of the usefulness of scout films of the abdomen in acute abdominal cases. Others, however, are still unaware of the occasional striking value of such films. Case VI is a typical example of an acute abdominal condition where earlier x-ray examination might have helped.

CASE VI (Fig. 7): The patient was admitted to the hospital on March 18, 1944, and died three days later. At the time of admission he was complaining of epigastric pain, vomiting, and some distention of the abdomen, extending over a period of six days. In 1943 he had had a peptic ulcer, which had perforated. The physical examination showed slight distention of the abdomen. Films taken March 21, three days after admission, showed no significant lesion in the stomach (a diagnosis of perforating ulcer had been made by the clinician). Flat films were taken and a diagnosis of mechanical obstruction of the small bowel was made. Surgery was immediately performed. The patient went into collapse on the operating table and died three hours later.

Comment: Here is a case of mechanical obstruction diagnosed from flat films, but a delay of three days before x-ray examination was ordered cost the patient his life. The films showed little or no gas in the small or large bowel. In spite of the great amount of attention the x-ray department has given to these cases, many general practitioners are still unaware of the advantages of flat films in acute abdominal cases. A history of a previous perforating peptic ulcer misled the clinician, so that intestinal obstruction was not seriously considered until three days later.


Figs. 8 and 9. Case VII. Figure 8, a postero-anterior view, shows moderate distention of the small bowel. Diagnosis is intestinal obstruction. In Figure 9, an anteroposterior view, the small bowel gas is hidden sufficiently so that a diagnosis would be difficult. These two films demonstrate the necessity of multiple views.

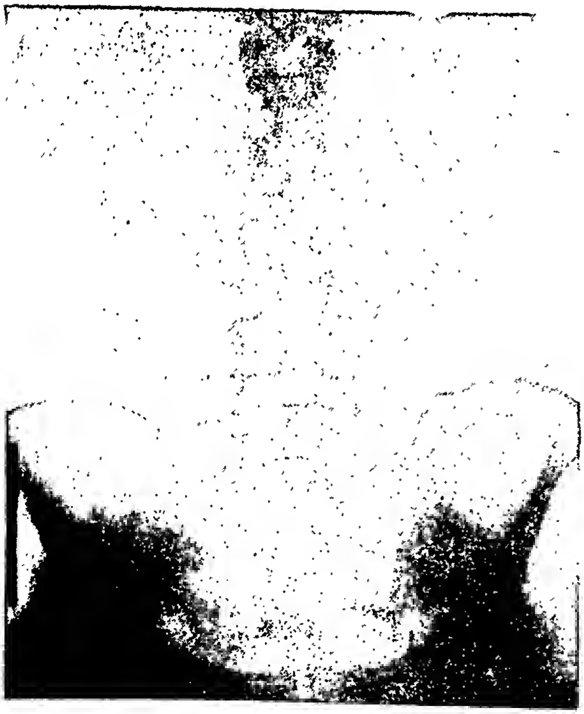


Fig. 10. Case VIII. Gas in small bowel and some in large bowel. No distention in any loops. X-ray diagnosis was "no obstruction." Surgeon disagreed and operated for obstruction. Postoperative course proved this case one of herpes zoster and justified the x-ray diagnosis.

CASE VII (Figs. 8 and 9): The patient was admitted to the hospital May 12, 1943, and was discharged as improved on May 30, 1943. He had been complaining of pain in the right lower abdomen for forty-eight hours, accompanied by nausea and vomiting. He had previously undergone an appendectomy and an operation for a femoral hernia.

Physical examination showed a tender abdomen with swelling in the right lower quadrant and enlargement of the scrotum, suggesting an incarcerated hernia. A flat film of the abdomen, taken on the day of admission, showed little or no gas in either the small or large bowel. This led to the diagnosis of intestinal obstruction, and an operation was immediately done. A band of adhesions was found, constricting the small bowel at the ileocecal valve. The hernia was not the cause of the obstruction. Recovery was uneventful.

Comment: Close collaboration between the clinician and x-ray department in this case led to a prompt diagnosis of intestinal obstruction, and surgery freed the devitalized loops of bowel, as shown in the films.

We have not always been convinced of the correctness of our interpretations. Frequently we have had to hedge and wait forrepeated examinations in cases which

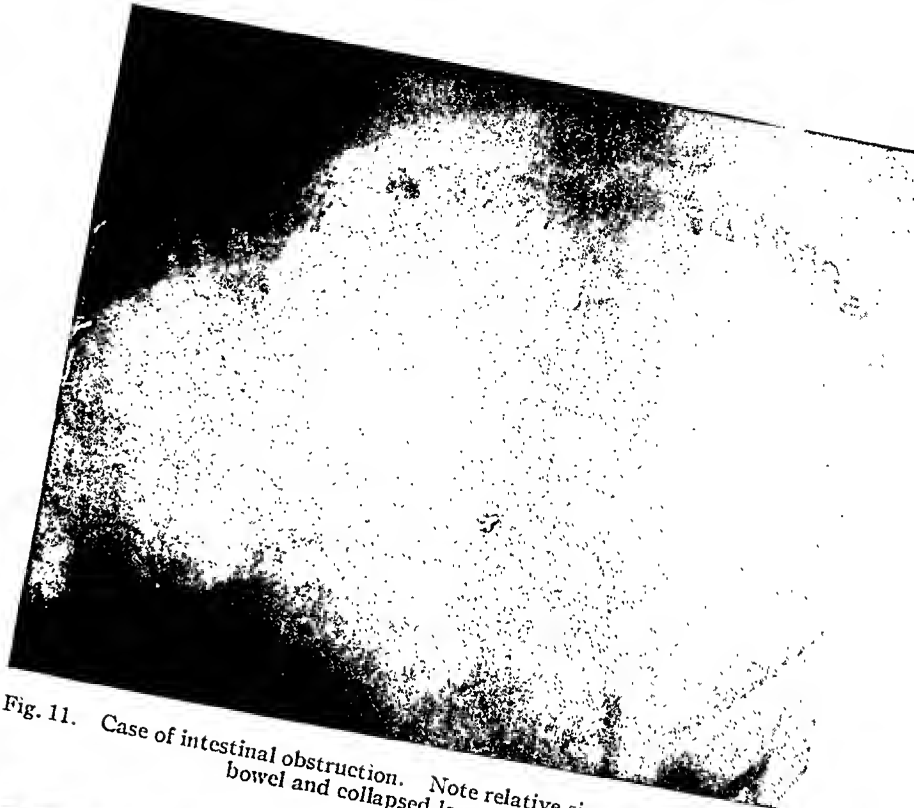


Fig. 11. Case of intestinal obstruction. Note relative size of distended small bowel and collapsed large bowel.

Fig. 12. A. Congenital hypertrophic pyloric stenosis, before operation. No gas in the small bowel. In the infant small bowel gas is normal. Its absence means an obstruction at the pylorus. B. Same case immediately after successful operation. Normal small bowel gas content.

Fig. 13. Note gas in small and large bowel. No relative distention of either is seen. Distal colon gas was removed by cleansing enema. This is a case of urinary colic (see arrows).

Fig. 14. At first glance there appears to be little or no gas in the abdomen. If obstruction was clinically in question, this film could be, on superficial examination, corroborative. On close examination the patch of gas seen is large bowel, so that obstruction is ruled out. Cleansing enemas and physics occasionally cause some diagnostic problems if obstruction is also suspected.

finally proved to be intestinal obstructions. Not once in this series, however, have we made a diagnosis of intestinal obstruction and been proved wrong. We present here a case which at first seemed to represent a diagnostic error. Postoperative findings showed the true diagnosis.

Case VIII (Fig. 10): The patient entered the hospital complaining of acute attacks of cramp-like pain in the right upper abdomen, radiating to the back. Constipation was habitual and the patient had always taken laxatives. There was no vomiting. An operation for the removal of a bladder stone had been done some eight years earlier.

Physical examination showed a distended abdomen with extreme tenderness in the gallbladder region. A diagnosis of cholelithiasis was made. An x-ray examination indicated no mechanical obstruction, normal kidneys, no calcified gallstones. The surgical consultant, however, advised operation for intestinal obstruction, and reported finding a band of adhesions around the sigmoid sufficient to have caused the abdominal cramps and a partial obstruction. Surgery had apparently been justified. We reviewed the films and again could not make a diagnosis of mechanical obstruction. We recorded this as an error against the x-ray department.

Several days after discharge, the patient reported vesicles developing in the right upper quadrant and, on re-examination, the obvious diagnosis of herpes zoster was made.

Comment: With due respect to the surgeon, we believe that the pain in the right upper quadrant and the entire right side of the abdomen was due to the developing herpes zoster and that the band of adhesions found near the sigmoid was probably not of any clinical significance from the point of view of obstruction.

CONCLUSIONS

In corroboration of our previous experiences, we present our further findings:

1. In our hands, the use of the Miller-Abbott tube was, as a rule, unsuccessful. In some cases it needlessly delayed operation, giving rise to fatalities. It frequently gives a false sense of security.

2. We urge immediate operation in all cases of mechanical obstruction. Our best

ig. 15. Urinary colic. A. Gas in large bowel, before cleansing enema. B. Same case after cleansing enema. Only distal colon gas is removed in these reflex ileus cases.

esults were obtained where no reliance 'as placed on the Miller-Abbott tube.

3. We feel, nevertheless, that the Miller-Abbott tube does have distinct value nd may sometimes be life-saving where peration is contraindicated and in some ases of postoperative distention.

4. We urge accurate x-ray study of all ases of postoperative distention after the hird day, to help differentiate between eritonitis and mechanical obstruction. We feel that such patients, even though very sick, should be moved to the x-ray lepartment for proper and dependable films. Only in this way can we make an early diagnosis of "postoperative convalescent obstruction."

5. Examples of the "no gas" case of obstruction have been described. These caused us considerable difficulty in diagnosis. Repeated examinations cleared up the diagnosis in practically every case.

6. The roentgenologist can and must assume greater responsibility in determining the need for surgical intervention in these cases.

7. A Miller-Abbott tube or a Levine tube will frequently stop vomiting, giving a false impression of improvement. We now depend considerably on the x-ray films for determining the cause of the distended abdomen. The frequency of vomiting and the rectal passage of small stools are important but not conclusive.

8. Flat films of the abdomen in acute abdominal cases will frequently reveal the correct diagnosis.

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Radiology of the Chest: Its Evaluation in the Prevention of Tuberculosis[1]

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THE DISEASE

TUBERCULOSIS is an infectious disease which, for its transmission, necessitates contact by a susceptible patient with infectious material. Some persons appear to be naturally susceptible; in certain cases susceptibility appears as a familial tendency: the children of infectious persons, being constantly exposed to infection, frequently fall victims to it. There is evidence that we in Great Britain have acquired considerable resistance to the disease but that this resistance can be broken down by debilitating influences such as lack of necessary foodstuffs, sunshine, and open air, by constant fatigue, overcrowding and bad ventilation, by damp and cold, and by illnesses, particularly those associated with respiratory infections or fibrosis.

Public health measures aimed at isolating and educating the infected and remedying the defects mentioned above resulted in a steady decline in the incidence of tuberculosis, and there is every reason to believe that more enthusiastic and consistent work along these lines would cause a considerable further reduction. In the early years of the war, when its restrictions, impositions, and black-out conditions forced the population to share these debilitating influences with a large number of infectious persons (estimated as at least 50,000) who were deprived of medical aid because of the shortage of doctors, we saw a definite increase in the number of cases of tuberculosis.

Like all other infectious diseases, tuberculosis has an incubation period which is followed by an onset with definite clinical signs and symptoms. These vary according to the susceptibility of the patient and the virulence of the infection. In some cases the gravity of the disease becomes apparent soon after the onset; at the other end of the scale are those patients who exhibit signs and symptoms of a relatively mild respiratory disorder which are mistaken at first for those of a cold, or influenza, and, if they continue, of bronchitis. The majority of these milder cases terminate in complete recovery; we only know of their existence because we find evidence of old healed lesions. Some cases, however, show but temporary recovery, lasting for a variable time, from a few months to ten or more years, after which a recurrence of activity of the disease develops; the symptoms of such recurrences vary in severity and call for treatment accordingly. The gradual development of a chronic inflammatory condition of the lungs with its bouts of quiescence and activity may not attract attention to the gravity of the disorder. During quiescence the patient may feel quite able to work and enjoy a certain amount of leisure over a period of twenty to thirty years or more, and neither he nor his doctor may suspect the true nature of the disease. But for its infectious nature and the possibility of others acquiring it, tuberculosis for the greater period of its duration may not present the distressing symptoms of such pulmonary conditions as silicosis, bronchiectasis, and asthma.

Diagnosis of infective cases can be established by examination of the sputum, but of late years the spectacular demonstration of tuberculosis by radiography has led doctors to consider the latter as a means of early diagnosis. How has this been brought about?

RADIOLOGY

With the discovery of x-rays by Roentgen, in 1895, began the attempts to demonstrate tuberculous foci in the lungs.

[1] Accepted for publication in January 1945.

In the early years, because of the necessarily long exposures during which it was impossible to keep the patient or his lungs sufficiently stationary, only the grosser lesions could be detected. Gradually the time of exposure was progressively reduced by the introduction of units having a greater output of x-rays and the manufacture of faster and faster films and intensifying screens. The quality of the radiographs was also improved by perfecting the control and output of the tube and reduction of its focal point, as well as by employing emulsions on film and screen of the finest grain. These factors permitted the radiologist to produce radiographs which showed the more minute detail of all structures having contrast density. But this detail was not understood, and, as in so many spheres into which radiology has been introdueed, bold interpretations were advanced before the normal and its variations had become known. The vascular pattern of the lung, for instance, with its infinite variety, was frequently and still is interpreted as hilar tuberculosis with peribronchial spread. Such errors could not escape the attention of able physicians, who were thus taught to distrust radiographic interpretation.

Gradually, however, the work of reliable radiologists has convinced the physician that radiology can make important contributions toward the elucidation of clinical problems. Today, with good technic, it is possible to produce radiographs showing typical appearances for many conditions, including tuberculosis—so typical that even the novice with average intelligence can readily be taught to recognize them at a glance. It is perhaps this ready recognition which is really responsible for many misinterpretations, because, having acquired this superficial knowledge so readily, the novice is apt to assume the cloak of competence and seek little further for learning. Without experience, he fails to appreciate the full significance of the following: (1) that artefacts on the films have appearances which may simulate pathological lesions; (2) that the radiograph is a measure of the relative densities of all the structures between the x-ray tube and the film, including all the material or tissue on the skin of either side of the area covered and all structures within; (3) that certain protuberant structures, as the nipples, breasts, male generative organs, warts, muscle folds, etc., when pressed against the film, screen that part of it with which they are in close contact from the secondary radiation that fogs the adjacent film, and thereby produce a transparency which, in contrast to its surroundings, suggests an increased density and may be interpreted as a foreign body within; (4) that all the structures of the area covered by the film, no matter how far they may be separated anatomically, are brought together in the plane of the film into one conglomerate mass which presents a kaleidoscopic variation of appearances, not only as the result of disease in any of the tissues but, what is perhaps still more important to realise, even under normal conditions; (5) that the lesions in each disease have many different appearances and yet many diseases may at one stage show appearances which are indistinguishable from one another; (6) that a lesion must have acquired a certain size or produced a relative contrast density in the adjacent tissues before it can be visualised radiographically, so that there is an early stage in all lesions in which the radiograph is of no value; (7) that in disease the radiographic evidence lags behind the clinical symptoms and signs, and this applies at the beginning as well as in the convalescent stages.

Failure to appreciate these features, particularly when associated with inadequate clinical investigation, is responsible for dangers to the patient which are more real than apparent. I have known the chest to be repeatedly needled for pus because the radiograph showed a spindle-shaped opacity on the lateral wall of the thorax, due to projection of the opacity of the biceps (the radiograph having been taken with the arm against the patient's side) over the chest wall. Operative meas-

ures have even been performed or lengthy investigations made to seek information as to the nature of an artefact on a film and to explore the normal and its variations, which were not known. On the other hand, neglect has followed the mistake of interpreting the appearance of pathological conditions as that of normal structures.

Obviously, therefore, it is the duty of any medical practitioner who wishes to take the responsibility of interpreting radiographs to acquire the knowledge which would preclude the errors mentioned above. He is held responsible in the courts in certain cases if he fails to have a radiograph taken. Is he not even more responsible if he attempts to interpret radiographs of which he has little or no knowledge? We as radiologists are in some measure to blame for the present state of things. We have paid more attention to spectacular demonstration of radiographic appearances than to a careful study of just what those appearances have meant. The film has been the attractive feature rather than the report. Most of our contributions to the literature and to society meetings have been devoted to a demonstration of what the radiograph can show, and there has been far too little attention or emphasis on the fact that there are many more conditions of which the radiograph will not give the slightest indication. Because of this, clinicians have come to depend upon the radiograph for help in all cases and they are so disappointed when they receive negative reports in the presence of marked clinical signs and symptoms that they tend, sometimes with no reason whatever, to attribute the failure of radiographic contribution to the poorness of the radiographs or the incompetence of the radiologist. No wonder they are tempted to do their own radiology. To this there can be no objection, providing they expend every reasonable effort to study all the factors concerned with the production of the radiograph and its interpretation, and to keep abreast with all the advances in radiology. But to do this, they must become radiologists, for those of us who devote our whole time to radiological study have problems every day which we find difficulty in solving. In the solution of these we often obtain the best help from the physician who has made a careful study of the clinical aspects of the case; without this study we should be deprived of help and the solution would escape us.

There is probably no branch of medicine or surgery where co-operation between clinician and radiologist is productive of so much good work for the patient or where failure to co-operate can lead to so much error in judgment and treatment as in tuberculosis. Neglect in either specialty tends to lead one or the other to seek his own facts in a sphere in which he is not experienced. To do this, he frequently neglects to obtain the best from his own particular specialty, with the result that he can make little or no useful contribution and his judgment suffers.

The reason why cases of tuberculosis are missed is that no attempt has been made to exclude the possibility of its occurrence by examination of the sputum for the bacillus or by radiography of the chest. Either or both of these may give positive evidence or such as will keep the case under suspicion. In some instances the sputum provides the evidence before the lesions have acquired a size or density permitting radiographic demonstration. An even greater number of lesions will not be recognisable on the fluorescent screen. The clinical signs and symptoms may be recognised by the experienced physician at a time when radiographic appearances are normal, *i.e.*, the radiographic evidence lags behind the clinical. In some cases the patient is so susceptible that the clinical signs are rapidly followed by extensive radiographic signs, so extensive that some clinicians have erroneously regarded this as evidence that the disease was missed because it was previously symptomless and no radiograph was taken. Even in the less susceptible patient, if the clinician persists in his suspicion and has a fur-

ther radiograph taken after an interval of time, depending upon the degree of susceptibility and upon the virulence of the organism, roentgen evidence will be forthcoming in the positive case. Failure to seek this radiographic confirmation followed by temporary or permanent improvement in the general condition will result in failure to diagnose the disease. The patient may now unsuspectingly become a chronic carrier.

Since tuberculosis is an infectious disease having an incubation period and a further period which may be without radiographic evidence, we must, if we are to use radiology as a preventive measure, ask for early roentgen examination of all persons showing signs or symptoms of chest disease and sequestrate those with negative findings until, after an interval of say three months, a repetition of the examination confirms the earlier observation. In addition, we must repeatedly examine all those persons who are known to have been in contact with the disease. Those who are found to be infective must be segregated or at least taught how to avoid infecting others. The latter would appear to be the only course available and it must obviously depend upon the goodwill and determination of each patient. This in itself is a demand unlikely to be met in all cases, for the chronic disease permits of long life and practically normal activity, in which forgetfulness cannot be surprising or entirely blameworthy. This program represents a formidable demand upon medical and technical staffs, equipment, and accommodation, but it might be met with multiple teams using routine mass radiography. Anything short of this can hardly represent a useful contribution to preventive medicine, for the infectious person who has not been examined can spread the disease.

Radiographic examination, at three-month intervals, of groups of persons qualifying, say, for the Services, the police, nursing or medical students, will permit us to detect all those with radiographic signs. Some with early infection would be missed, but they would be picked up on the next examination in three months. The necessity for the repeated examinations is due to the fact that we are dealing with a selected group of persons who are in no way prevented from coming into contact with infection at home or during recreation. Unless the infected are detected early, they too could become unsuspected centres of infection, the more dangerous because they had been reported as free from radiographic signs of disease. By such enforced periodic examination tuberculosis in those groups could be kept at a very low figure. It would be possible to lower the figure and perhaps even extend the interval between examinations if we could prevent infection from outside the groups. For regularly repeated radiographic investigation of the entire population—and this would be necessary if possible sources of infection are to be eliminated—the prodigious demand upon staff, equipment, accommodation, and time of all concerned, is beyond all reason when so many aspects of life call for attention. To use group examinations to exclude individuals from certain professions or callings is not without serious injustice to them and loss to the calling; they are still members of the community; they have a right to live and receive what treatment is desirable.

EVALUATION OF RADIOGRAPHIC FINDINGS

But what of those who are found to have radiographic evidence of tuberculosis? Many persons are infected and recover completely without any specific treatment, often without knowledge of the nature of their illness. Some of these will show minimal radiographic lesions, but the discovery of these in a general survey of symptomless persons has not the importance it has in patients who are examined because they have symptoms. As I have previously stated—and the statement has been endorsed by several writers—the patient at the onset of the disease may show clinical signs and symptoms, may even have tubercle bacilli in the sputum, yet the

radiographic appearances may be normal. How seldom are we able to show radiographic evidence of miliary tuberculosis when the physician requests it because of the gravity of the symptoms it has produced? The most significant and earliest indications of tuberculosis I have found not accidentally during examination for something else or in routine chest radiography, but in patients suspected by the physician to have recently contracted the disease. In some cases these indications have appeared in a patient who a month or so before had no signs of them; in some cases they can be seen clinically and radiographically to develop rapidly in spite of every known method of treatment. Such minimal lesions do not represent the "healed" form which we accidentally discover by surveys. The discovery of the latter in a symptomless patient involves the authority in the responsibility of determining their significance. This may mean repeated radiography, periods of observation, and extensive investigations, and in the end, because the patient remains symptomless, perhaps for several years, he eventually receives the instructions which well might have been given in the first instance, *i.e.*, to report to his doctor or clinic if certain signs or symptoms develop; and develop they may at any time, five, ten, or twenty years later. Or they may never develop, but during all this time the life of the patient, his social contacts, his living, his insurances have been seriously interfered with without conferring anything but expense on the community.

Brian C. Thompson, who is apparently unfamiliar with patients showing the early clinical signs and symptoms of pulmonary tuberculosis, since he regards them as "freak cases," which he states "can usually be traced to poor x-ray technique or a clerical error in the bacteriological department," is characteristically an enthusiastic advocate of mass radiography. Yet he states: "While there may be no statistical proof that detection and treatment of a small early lesion ultimately improve the individual prognosis, there is not a scrap of evidence to the contrary," and: "Re-examination of persons initially x-ray negative, from a selected group of those continuing in contact with a sputum-positive associate, is so unprofitable that it can be practically neglected."

The members of the public, through its ministers, who were advised by mass radiography advocates, have been told in the papers, on the wireless, and at multiple demonstrations, *that by early detection and treatment the disease can be cured.* Surely they have a right to statistical proof of this if they are to submit to the examination and help to bear its great cost. Further, if we can neglect those known to be continuing in contact with a sputum-positive associate, why bother about the majority who are not so unfortunate?

The chronic cases of pulmonary tuberculosis may show extensive fibrosis of the lungs, cavity formation, and many other complications, but patients who have had the advantage of early diagnosis and sanatorium treatment may be discharged from the sanatoria with these lesions. As long as we cannot enforce compulsory segregation, the most to be hoped for in these cases, from the aspect of preventive medicine, is that they will not infect others; but, except for the publicity of their illness and, we hope, the education they have profited by, they may become joint agents of infection with the undiagnosed cases.

There are many other criticisms which can be levelled at the principle of mass radiography and the manner in which it is conducted. Many of these have been stated in previous papers (1–3).

CONCLUSIONS

The early signs and symptoms of pulmonary tuberculosis should be well taught to all medical students. They should also be taught that it is essential to include an interpretation of a radiograph of the chest by an expert in the records of the findings obtained at a thorough clinical investigation of all patients with signs and symptoms of pulmonary disease; that when the radiographic appearances in such cases are

normal, a further radiograph should be made at a later date, the interval depending on the clinical findings; that treatment depends upon the clinical aspect of the case and not on the radiographic changes—the latter may appear extensive in a patient who is apparently fit—even sanatorium treatment cannot improve upon this.

Periodic roentgen examination should be made of all those in contact with pulmonary tuberculosis and of all those who are engaged in industries associated with dust and noxious fumes known to cause damage to the lungs. The doctor should be given every facility for obtaining a chest radiograph in any case in which he desires it.

In view of the very great expense in time and money which would be involved in carrying out the above recommendations, mass miniature radiography appears the cheaper solution. Regularly repeated mass radiography of a selected group of the population, *i.e.*, the Services, schools, universities, professions, or trades, may be a means of excluding persons from that group who are likely to infect others, but for the population as a whole this is not a material contribution to preventive medicine and it may impose an injustice on the members of the group who happen to show radiographic signs, though these may be of no clinical significance.

Mass radiography of the population without compulsory segregation of all infected persons would involve so many medical and technical offices and so much time, equipment, and accommodation, without materially contributing to preventive medicine and without assurance of freedom from error, that it is unreasonable.

We have neither the trained staffs, equipment, nor accommodation to treat all the infective patients whom we know or find with ordinary present-day methods.

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Vertebra Plana (Calvé)[1]

Report of a Case

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IN A PAPER read before the British Orthopedic Association at Bologna in 1924, Calvé (1*a*) first described a lesion of the vertebral body which he called "a localized affection of the spine suggesting osteochondritis of the vertebral body with the clinical aspect of Pott's disease." At that time he had but two cases to present, one observed by him and one by Brackett (2) of Boston. Four years later, when he wrote his essay for the Robert Jones Birthday Volume (1*b*), he had collected only seven more cases, none of them his own.

In the United States, Buchman (3*a*) was the first author to aid in crystallizing this new disease entity by reporting two cases in 1927 and differentiating the condition from vertebral epiphysitis, or Scheuermann's disease (3*b*). When Sundt (4), a Norwegian orthopedist, searched the world literature in 1935, he was able to gather 21 recorded cases. Several of these, however, were not Calvé's disease in the opinion of Dale (5*a*), who reported two cases, one in 1937 (5*b*) and one in 1942 (5*a*). Sundt's article contains an extensive bibliography. Mezzari (6), reviewing the literature in 1938, mentioned 27 published cases, but added that, on the basis of a questionnaire suggested by Lindstroem, only 17 were typical examples of the disease as described by Calvé. In the United States, cases have been reported by Kuhlman (7) and Mitchell (8); in South America, by de Albuquerque (9) and Allende (10).

The confusion of nomenclature in the literature increases the difficulty of coming to a correct diagnosis. Many different names have been applied to this condition, the more common being osteochondritis of the vertebral body (Buchman, 3), osteochondritis deformans vertebrae (Voke, 11), infantile pseudospondylitis (Mezzari, 6), and vertebra plana (Calvé, 1). Because of the great degree of flattening of the vertebral body, I prefer the descriptive term, vertebra plana. There is no evidence in support of osteochondritis, as the disease is not characterized by inflammation of bone or cartilage.

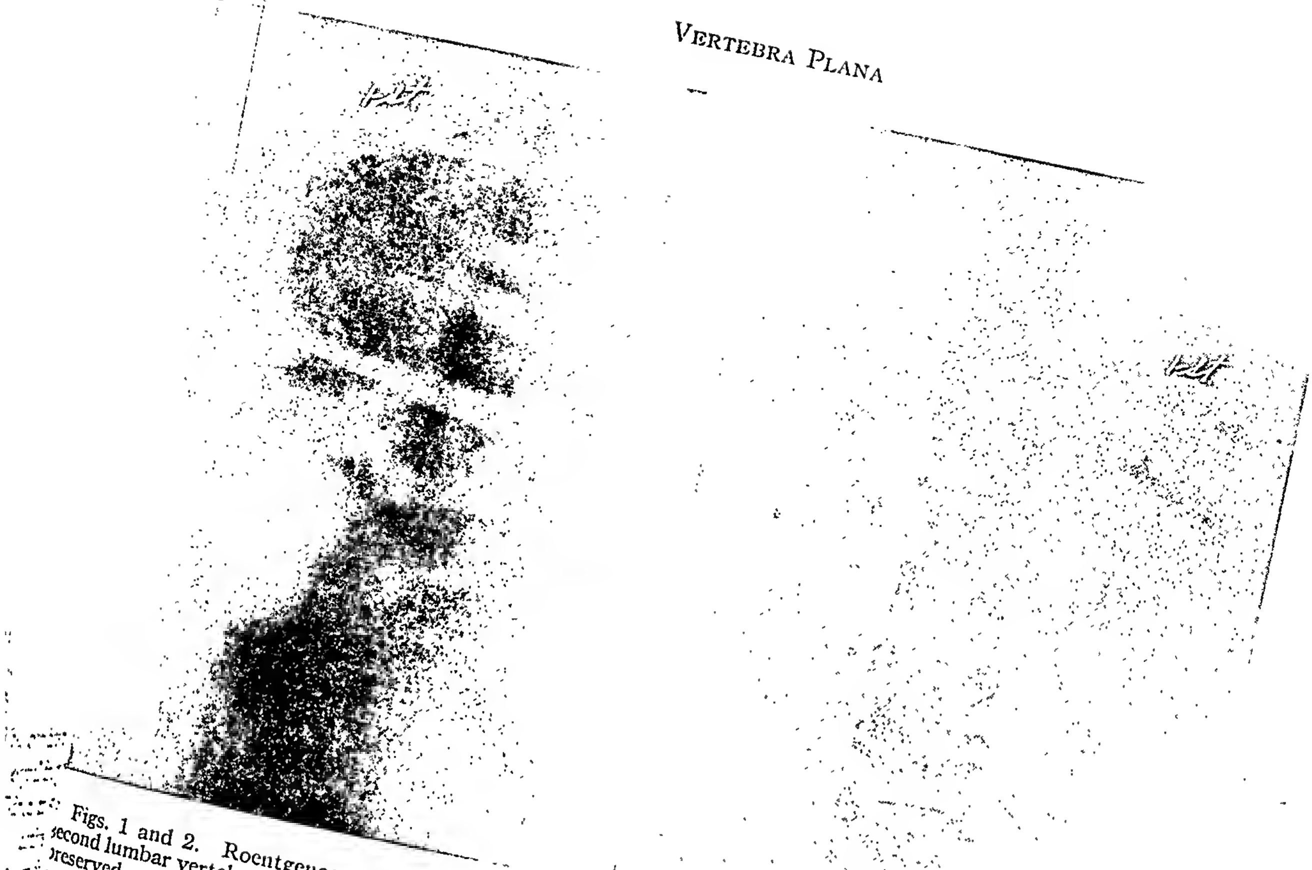
Vertebra plana occurs in children between two and fifteen years of age. Most frequently, according to Kuhlman (7), it is observed in those whose ages range from five to ten years. Mezzari (6), however, believed the age of predilection to be between four and seven years. In the case to be presented here the age of the child was three years. The condition is observed with approximately equal frequency in the two sexes. The children most commonly affected are healthy, active, and often moderately overweight; in these children the epiphyses are growing more rapidly than in those who develop more slowly.

ETIOLOGY

The present conception of vertebra plana is that it is due to a primary aseptic necrosis of the body of the vertebra, which in turn is the result of an interference or a blocking of the blood supply. The cause of damage to the blood vessels, circulatory dysfunction subsequent to a disease of the vasomotor fibers or a change in the arterial tonus, is unknown. Vertebra plana follows in the spine a course similar to that of coxa plana in the hip.

The etiology is not definitely known. In a fairly high percentage of cases an acute infectious disease precedes the onset of symptoms. In most of the cases reported there is a history of a relatively slight trauma. Other suggested causes include endocrine disturbance, rickets, and congenital anomaly. Buchman (3*a*) believed there is "an imbalance between the static

[1] Accepted for publication in December 1944.



Figs. 1 and 2. Roentgenograms made on Oct. 26, 1933, a few days after the onset of symptoms. The second lumbar vertebra is compressed and has a wedge-shaped appearance. The intervertebral spaces are well preserved. The anteroposterior view shows a collapse of the second lumbar vertebra. There is no evidence of a paravertebral abscess.

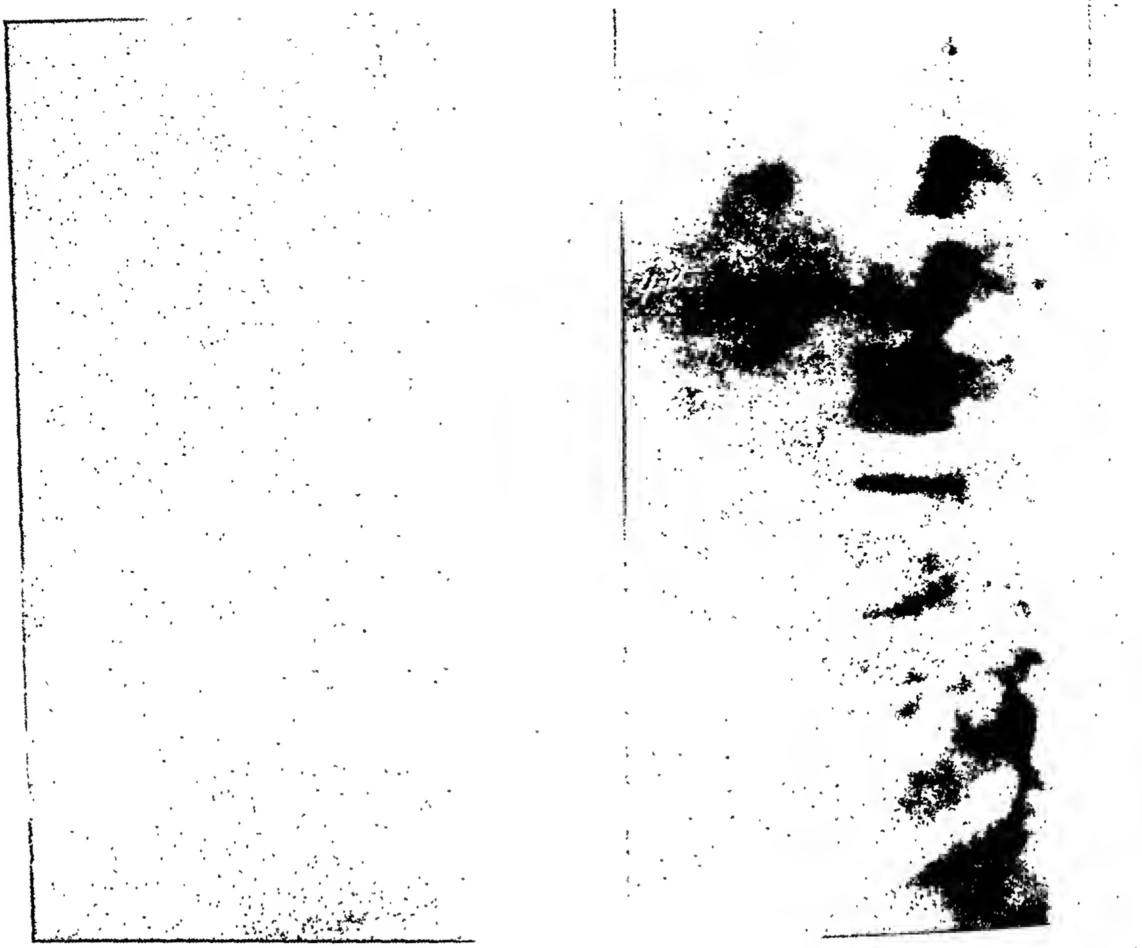
demand and the static capacity." Calvé (1) originally favored infection as the most probable causative agent. Later, he concluded that the disease is a process of aseptic necrosis.

Overton (12) offered the plausible theory that when the demand of the epiphysis for nourishment is greater than the supply, nutrition of the epiphysis is insufficient. As he observed, during the most active period of growth of the epiphysis the vascular system is taxed to its physiologic limit in supplying the needed nutrition; with a demand for increased nutrition, requiring of necessity an increase in the circulatory supply to the epiphysis, imbalance occurs, and because of the inadequate nourishment anemia results in the central subchondral zone, that part of the epiphysis which normally has the least supply of blood.

Harbin and Zollinger (13), after an extensive review of the literature, concluded that localized necroses of bone should be considered a single entity regardless of the part of the skeleton involved. They classified the disease as an osteochondritis of the growth centers.

PATHOLOGY

Pathologically, aseptic necrosis takes place, with secondary fragmentation and collapse of the body of the vertebra, followed by regeneration of the bone. The pathologic process is similar to that described by Hodges, Phemister and Brunschwig (14) in Legg-Calvé-Perthes' disease of the hip and in other necrotizing lesions of bone. The necrotic bone breaks down and is gradually compressed. At first the vertebral body assumes a wedge-shaped deformity. Gradually it is reduced to a thin wafer-like disk, the dead bone being compressed into the remaining cancellous spaces. The intervertebral disks are preserved. The first stage of disintegration



Figs. 3 and 4. Roentgenograms made thirty-four and seventy-seven days after those reproduced in Figs. 1 and 2. On Nov. 30, 1933 (left), the body of the vertebra appears as a thin dense disk. The intervertebral spaces are of normal width. After seventy-seven days (right), the stage of compression and osteolysis is complete, ending the period of degeneration and disintegration, the first of the two distinct phases of the process. Only a wafer-like remnant of the old body remains (Jan. 12, 1934).

and collapse is followed by a protracted reparative period in which regeneration of the bone occurs. According to Phemister (15), repair of aseptic dead bone is accomplished after the revascularization and invasion of necrotic bone by osteogenic tissue, the dead bone being replaced by new bone. The rate and completeness of replacement depend largely on the amount of revascularization and on freedom from weight-bearing. The longer the period of immobilization, the more rapid and complete is the restoration. The pathologic study of Mezzari's classical case showed that the necrosis of the vertebral body was entirely aseptic in character, without any trace of inflammation, with revascularization and partial regeneration of the bone (6).

SYMPTOMS

In his early description of this disease entity, Buchman (3*a*) mentioned that it is characterized by an insidious onset, moderate or slight pain, fatigue, night cries, muscle spasm, tenderness, and knuckle formation or deformity in the form of generalized kyphosis or scoliosis. In proportion to the pathologic change demonstrated in roentgen studies, the symptoms seem to be mild, as they were in the case here reported.

ROENTGEN DIAGNOSIS

Roentgenograms establish the diagnosis. Usually only one vertebra is involved, although it is reported that occasionally more than one may be affected. The two distinct phases of the process are well illus-

ated in the case presented. In the early ages, the period of degeneration and dis-tegration, there was a wedge-shaped de-rmity of the involved second lumbar rtebra (Figs. 1 and 2), with a preserva-on of the intervertebral disks. This was pidly followed by progressive flattening d compression of the vertebral body un-a thin disk of bone of increased density

Fig. 5. Roentgenogram made July 6, 1934, nine nths after the onset of symptoms. The body of the tebra has become elongated, and there has been a ht increase in its height. The second phase, the iod of regeneration and reconstruction, has now gun.

mained (Figs. 3 and 4). The adjacent tervertebral disks were of normal width, slightly wider than normal. The in-grity of the intervertebral disks above d below the affected body was char-teristically maintained. After the period degeneration was completed, the phase regeneration or reconstruction began. ine months after the onset, the vertebral dy had become elongated, with a slight crease in the height (Fig. 5). The inter-rtebral spaces were wider than normal. he growth of the body was progressive,

Fig. 6. Evidence of the increased height of the vertebral body and of the great regeneration of bone is presented in this roentgenogram, made Dec. 30, 1937, four years and two months after the onset. Note the anteroposterior increase in the length of the vertebral body with concave indentations along the superior and inferior borders, caused by nodular protrusion of the nucleus pulposus, or Schmorl's nodes.

but the period of growth was greatly protracted (Figs. 6 and 7). Eleven years after the onset, the body had attained approximately 100 per cent of its normal size (Figs. 8 and 9). The intervertebral spaces were well preserved.

DIFFERENTIAL DIAGNOSIS

Clinically, vertebra plana is doubtless frequently diagnosed as tuberculosis of the spine. In this latter condition, chiefly a disease of childhood, an irregular destruction of one or more vertebral bodies is followed by their collapse and involvement of the intervertebral disk. Thinning of the intervertebral disks may be the earliest sign of the disease. There is one type of tuberculosis which strongly simulates vertebra plana. Here the flattened body of increased density represents two fused collapsed bodies as revealed by two neural arches attached posteriorly to the flattened mass. Vertebra plana is, therefore, easily distinguished from tuberculosis of the spine

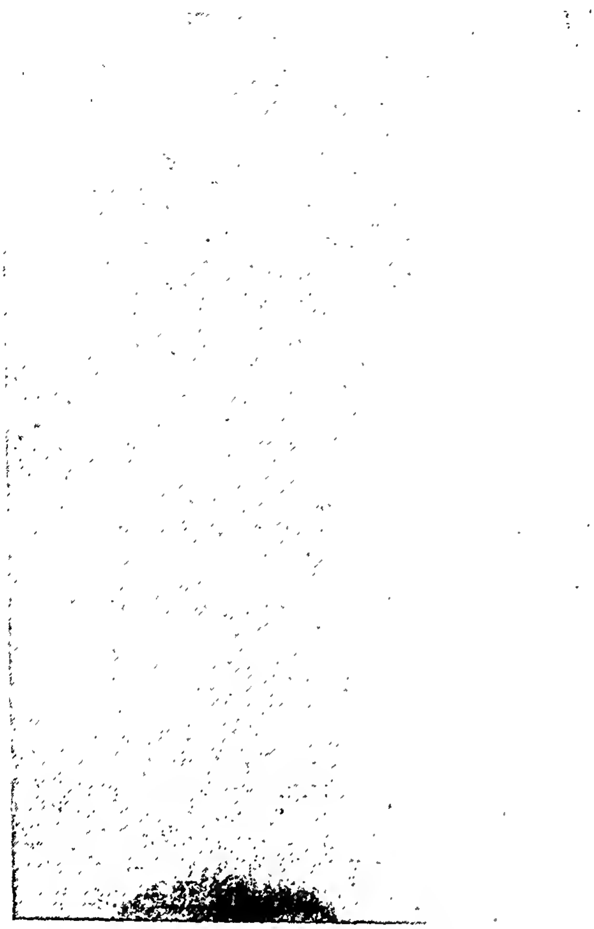


Fig. 7. Roentgenogram of Sept. 30, 1941, showing further growth of the vertebral body. It has now attained 75 per cent of its normal size. The reparative stage has been greatly protracted.

by the appearance of a flat body of increased density, the absence of loss of the intervertebral space, the regeneration of the body, and the fact that almost without exception only one body is involved. The destructive changes in tuberculosis of the spine are frequently accompanied by a fusiform shadow about the diseased area due to a paravertebral abscess.

Vertebra plana is a distinct entity to be distinguished from the so-called vertebral epiphysitis or Scheuermann's kyphosis dorsalis juvenilis. This is usually a disease of early adolescence. There is, as a rule, a well defined dorsal kyphosis with involvement of several thoracic vertebrae, in most instances limited to the lower half of the thoracic spine. The most constant change is irregularity of the upper and lower surfaces of the vertebrae, particularly at their anterior margins. This is usually accompanied by an irregularity in epiphyseal calcification. The epiphysis appears to be fragmented. With these changes there is a slowly progressive wedging of the involved vertebral bodies.

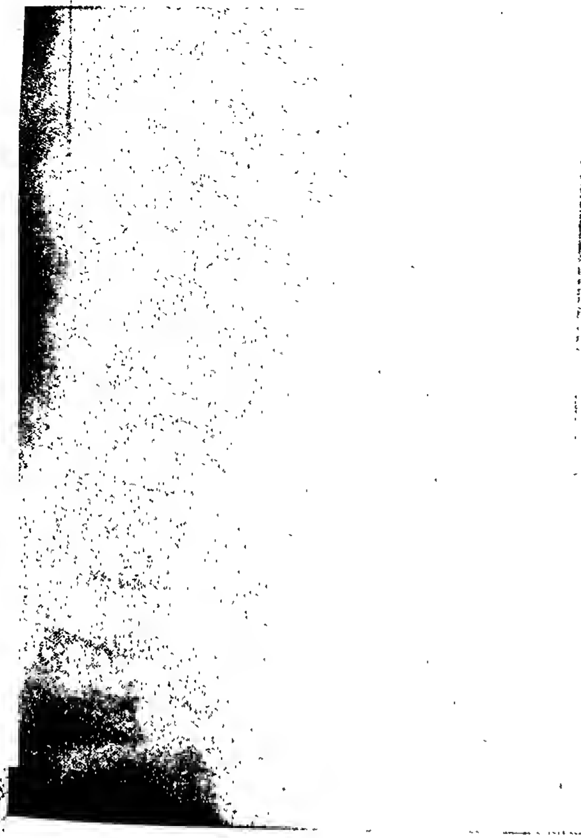
In hyperfunction of the parathyroid glands in which there is a disturbance of calcium metabolism, there is a general decalcification involving the entire skeleton. One or more thoracic vertebrae may have a uniform shortening without involvement of the intervertebral disks.

Osteoporosis and metabolic disturbances are also to be considered. In the rare forms of hunger, traumatic, and metabolic decalcification, there may occur a flattening of the vertebrae with much swelling of the nucleus pulposus, producing a concave deformity on the superior and inferior borders of the weakened decalcified vertebral bodies.

Malignant tumors of the spine are likewise to be differentiated. Such lesions are rare in childhood. Sarcoma, Ewing's tumor, and hypernephroma all produce destruction of vertebrae without distinguishing characteristics. A giant-cell tumor, myeloma, or hemangioma may show typical changes. Collapse of vertebral bodies with preservation of the intervertebral space and articular cortex is also indicative of a metastatic malignant neoplasm.

TREATMENT AND PROGNOSIS

Recumbency and immobilization of the spine by means of a plaster-of-paris jacket have given satisfactory results in the treated cases. Adequate treatment by prolonged immobilization shortens the reconstructive phase, while activity and inadequate immobilization prolong it. A favorable prognosis is warranted as to the ultimate outcome. The remaining deformity does not interfere with activity. In the case presented, complete regeneration was demonstrable after eleven years; a shorter time might have been required had the period of immobilization been sufficiently prolonged.



Figs. 8 and 9. Roentgenograms made Oct. 19, 1944, eleven years after the onset of the disease. The complete regeneration of the vertebral body is well demonstrated in the lateral view. The height of the vertebra is the same as that of normal lumbar vertebrae. The concave indentations along the superior and inferior borders are still evident. The anteroposterior view shows the complete regeneration of the body of the vertebra with no evidence of a paravertebral abscess. The intervertebral spaces are well preserved.

REPORT OF CASE

A white boy, aged 3, was admitted to Columbus Hospital, New York, on Oct. 25, 1933. His mother related that some days previously he had fallen from a trunk about 2 feet in height, but had not complained, although he had fallen on the spine. A few days later she had noticed that, when he wanted to pick up something from the floor, he would bend the knees and keep the back straight, without, however, complaining of pain. One week later he complained of pain in the region of the umbilicus. At the time of admission he walked in a position of lordosis, with the abdomen protruding and the shoulders thrown back.

The child was well developed, well nourished, and healthy. There was slight tenderness on pressure over the lumbar spine. Neurologic examination, made by Dr. David Impastato, gave no evidence of sensory changes in the gluteal region or lower limbs, nor was there any change in the reflexes of the lower limbs. There were no pathologic reflexes and no atrophy nor fibrillation of the gluteal muscles.

The temperature was normal. The hemoglobin estimation was 75 per cent; the red blood cell count was 4,250,000; the white blood cell count was 7,400, and the differential count showed mature neutrophils 60 per cent and lymphocytes 30 per cent. Reaction to the Wassermann, Kahn, and tuberculin tests was negative. The blood calcium content was 8 mg. per 100 c. c., and the sedimentation time was one hour and twenty minutes.

Roentgen examination was made on Oct. 26. Roentgenograms of the lumbar spine showed that the second lumbar vertebra was compressed and wedge-shaped in appearance (Fig. 1). The intervertebral spaces were, however, well preserved. An anteroposterior view showed a collapse of this vertebra (Fig. 2). There was no evidence of a paravertebral abscess. Roentgenograms of the skull, thoracic spine, thorax, pelvis, and extremities demonstrated no pathologic change in bones or joints.

On Oct. 27, a plaster-of-paris jacket extending from the shoulders to the hips was applied. Roentgenograms made on Nov. 30 showed that the body of the vertebra had become a thin dense disk (Fig. 3). The intervertebral spaces were of normal width. On December 23, against the advice of the attending physician, the parents took the patient home and soon removed the cast, but they permitted the child to be kept under observation. No doubt the re-

generative process would have progressed more rapidly had the period of immobilization been prolonged.

On Jan. 12, 1934, seventy-seven days after the initial roentgen examination, the stage of compression and osteolysis was complete. There remained only a wafer-like remnant of the old vertebral body (Fig. 4). After nine months had elapsed, the body of the vertebra was elongated and slightly increased in height; also, widening of the intervertebral spaces was apparent. The period of reconstruction was now under way, as shown by a roentgenogram made on July 6 (Fig. 5). On Dec. 30, 1937, four years and two months after the onset, roentgen examination gave evidence of greatly increased height of the vertebral body and of much regeneration of bone (Fig. 6). Roentgenograms made on Sept. 30, 1941, seven years and eleven months after the onset, demonstrated further growth of the body, which had now regained three-fourths of its normal size (Fig. 7). The regenerative phase is now complete, after eleven years, with full restoration of the height of the body (Fig. 8). The anteroposterior view shows the normal appearance with no evidence of a paravertebral abscess (Fig. 9).

At the present time, the patient, now in his fifteenth year, is overdeveloped and in excellent health. He leads a particularly active life. In spite of the slight deformity of the reconstructed second lumbar vertebra, he complains of no discomfort, and recent physical examination revealed no limitation of motion.

SUMMARY

Calvé's vertebra plana is almost without exception an affection of a single vertebra. It runs a cyclical course. The first or destructive phase of the cycle is relatively rapid, extending through a period of about two months. The second or regenerative phase is greatly protracted and may extend through a period of eight years or more.

The disease occurs in early childhood. The etiology is unknown. Pathologically, the process is one of aseptic necrosis of the vertebral body.

The characteristic roentgen findings are as follows:

(1) A wedge-shaped deformity of the vertebral body is observed in the early phase and is followed by a complete collapse or flattening of this body.

(2) The intervertebral spaces are not affected, or they may be slightly wider than normal.

(3) Regeneration of the vertebral body takes place without proliferation of bone.

(4) Only one vertebral body is usually involved.

A case is reported in which the patient has been under observation for eleven years. With completion of the degenerative phase of the disease in a few months, the regenerative process has since continued to be slowly progressive over this long period of time, and complete regeneration has only recently been demonstrated.

In view of the small number of cases reported, it is probable that the condition is mistaken for tuberculosis of the spine or the so-called vertebral epiphysitis, an error suggesting that made regarding coxa plana before Legg, Calvé, and Perthes (5, 8, 12) differentiated it from tuberculosis of the hip.

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Metallic Foreign Bodies in the Gallbladder: Case Report[1]

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THE RARITY with which inanimate foreign bodies spontaneously find their way into the gallbladder makes the following case seem worthy of recording. In this instance two metal needles or pins were found in the gallbladder of a patient who had no previous accident or operation to account for their presence.

Mrs. L. B., a 52-year-old white housewife, was admitted to Mercy Hospital (Toledo, Ohio), complaining of occasional attacks of sharp pains in the *left* upper abdominal quadrant, lasting a few hours and unrelated to meals or to exertion. She had never been jaundiced, had noticed no clay-colored stools, and even on close questioning gave no history of pain in the right side of the abdomen, back, or shoulder. Her past history was non-contributory. She had never had an abdominal operation.

Physical examination revealed nothing of note. There was no tenderness in the abdomen, and no enlarged organs or masses were palpable. There was no abdominal scar. Routine laboratory studies of the blood and urine gave normal findings.

Oral cholecystography, with Priodax, revealed a faint gallbladder shadow in normal position in the abdomen, and films taken in all projections showed two metallic foreign bodies within the gallbladder shadow, each having a faintly positive calculus near one end. They were freely movable, lying first parallel and later across each other (Fig. 1).

On the next two days, roentgen examinations of the colon and upper gastro-intestinal tract were done, the only noteworthy finding being a smooth shallow defect on the upper border of the duodenal bulb, as from external pressure. This was interpreted as suggesting adhesions between the bulb and the gallbladder, since in all projections the metal needles lay very close to the bulb and could not be separated from it by pressure.

The patient could not recall having swallowed any needles or pins but stated that for many years she had made her own clothing, so we may assume she had ample opportunity to swallow such objects.

Cholecystectomy was done a few days thereafter. The gallbladder, which was tightly adherent to the first portion of the duodenum, was removed intact with the cystic duct. On opening the gallbladder in the laboratory, a short piece of one needle was broken off and it was immediately apparent that both needles were much corroded. Each was 2.5 cm. in length and each had a very soft, friable stone around it, about 1 cm. in diameter. Unfortunately the specimens were exposed to the air for nearly a day before they were photographed, at which time the calculi had spontaneously disintegrated, probably consisting largely of cholesterol (Fig. 2).

Fig. 1. Cholecystogram, oral method, showing two metallic foreign bodies within the faint gallbladder shadow. The outline of one cholesterol calculus is fairly distinct. The other calculus, which was found at operation, cannot be distinguished.

The postoperative course was uneventful and the patient was discharged after two weeks. When seen several months later, she looked well and stated that she was free of all symptoms.

Most of the foreign bodies previously reported as being found in the biliary system are objects—such as bits of gauze—accidentally left after surgical operations. A complete search of the *Quarterly Cumulative Index* reveals very few reports of the spontaneous migration of inanimate foreign bodies into the gallbladder. Wallin (4) found a watermelon seed in the gallbladder of a cadaver during anatomical dissection. This had apparently migrated up the common bile duct from the duodenum. Only one instance similar to the case under discussion was discovered. This was reported in 1909 by Eastman (1). His patient, a woman, had had "left-sided pains (sug-

[1] From Mercy Hospital, Toledo, Ohio. Accepted for publication in December 1944.

estive of adhesions between the pylorus nd the gallbladder)" and attacks of gallstone colic. At operation the gallbladder as found to be adherent to the pylorus nd to contain numerous stones, together ith an ordinary short sewing needle enusted with bile salts. Eastman surmised iat the patient had swallowed the needle hile sewing, although she did not rememr doing so, and that it passed directly om the pylorus to the gallbladder. The irious occurrence of left-sided abdominal ain is noteworthy here, as this was also ie chief complaint in the case described oove.

Another case of this type, apparently nrecorded, is mentioned by Trousseau 3) who states merely that a M. Nauche ad found a pin as the nucleus of a gallone.

Toland (2) reviews the literature on reign bodies in the biliary tract in reorting his own case, in which a piece of auze had been left in the common bile uct after operation. He says: "It is gical to assume needles and other sharp bjects that have been swallowed and ached the pylorus might migrate by rect contiguity into the gallbladder. he curious circumstances that lead to ich migration are difficult to visualize." The only logical explanation in the case corded above for the presence of the edles in the gallbladder seems to be that ey passed directly into it from the first portion of the duodenum. This has previously been shown to have happened with one needle (1) but the occurrence of two such objects in the gallbladder seems doubly curious.

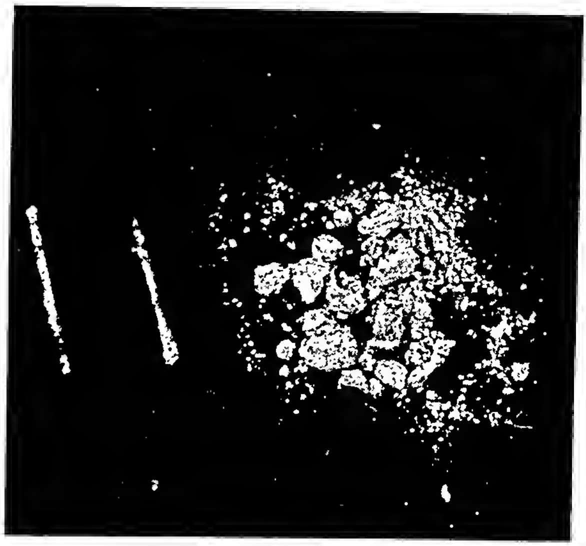

Fig. 2. Photograph of metal "needles," taken after the very friable calculi which had surrounded one end of each foreign body had spontaneously disintegrated.

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EDITORIAL

Congenital Atresia of the Esophagus

Medical history is replete with epics telling of diseases which have been conquered by new advances in medicine and surgery. These chronicles of patient and persevering study by enthusiastic scientists who have refused to admit the possibility of failure stand as milestones in medical progress. The recent successes reported in the treatment of congenital atresia of the esophagus with tracheo-esophageal fistula are representative of such achievements, indicating that a considerable number of cures can be obtained if a prompt diagnosis is followed by appropriate surgery.

The successful management of esophageal atresia depends upon the clinical recognition of its possibility, its roentgenologic proof, and its surgical treatment. It is essential that each of these steps be taken promptly if an ultimately good prognosis is to be assured.

The clinician should suspect the existence of a congenital obstruction of the esophagus when a newborn infant has an excess of mucus in its mouth, with attacks of choking and perhaps cyanosis when feeding is attempted. All the feedings are vomited, and death from inanition may threaten. Actual obstruction may be demonstrated by the introduction of a catheter, which fails to pass down the esophagus into the stomach, or by roentgen study.

Roentgen examination with the aid of a small quantity of iodized oil administered under fluoroscopic control will show a blind upper esophageal pouch, usually terminating at about the level of the second or third dorsal vertebra. The use of barium as a contrast medium is contraindicated because of the possibility of its aspiration and the consequent danger of a fatal bronchopneumonia. Even with lipiodol, care must be taken to avoid spilling over into the trachea and aspiration. To obviate any possibility of opaque material reaching the lung, Fuhrman, Dragutsky, Rook, and Grossman (1, 2) advocate a procedure which they designate aeroesophagography, in which the upper esophageal pouch is outlined by air injected through a soft rubber catheter introduced through the naris and passed downward toward the stomach under fluoroscopic guidance. Such a procedure should decrease the hazards of examination to a considerable extent and lessen the usually high mortality from bronchopneumonia.

In 1929 Vogt (7) classified cases of congenital esophageal atresia under three main headings. In Type 1 there is complete absence of the esophagus (very rare). In Type 2 both segments end in a blind pouch (rare). In Type 3 there is a fistulous connection with the trachea. This third type is further subdivided into Type 3 A, in which the communication is between the upper segment and the trachea; Type 3 B, in which the fistula is between the lower segment and the trachea; Type 3 C, in which both segments communicate with the trachea. Over 90 per cent of the reported cases are of Type 3 B. Demonstration of air in the stomach and intestines in the presence of complete obstruction of the upper esophagus indicates the presence of a communication between the lower esophagus and the trachea or a bronchus. This is an important observation from the point of view of surgical treatment.

Two types of operative procedure have been employed in an attempt to correct congenital atresia of the esophagus. The

earlier operation was done in multiple stages, designed (1) to feed the patient by means of a gastrostomy, (2) to close the fistula between the lower segment and the trachea, and (3) to drain the upper segment by exteriorization. Later an extrathoracic skin tube must be constructed if the procedure is to be termed successful. The second or direct method contemplates the restoration of the continuity of the esophagus by direct anastomosis. This operation is carried out in one stage. After extrapleural exposure, the fistula is ligated and the two segments are anastomosed. If this is successfully accomplished, the normal swallowing act is restored. This seems definitely to be the operation of choice.

The first case successfully treated by the indirect method was recorded by Leven (6) in 1941, although at the time of the report the extrathoracic tube to replace the intrathoracic esophagus had not been completed. Up to the present time 34 cases treated by the indirect method have been published. Fifteen of the patients were reported as living, but in only two had the artificial esophagus been completed.

In 1943 Haight and Towsley (3) reported the first successful direct anastomosis of the two esophageal segments, their patient at that time having reached the age of one year. Their success was preceded by numerous reports of failure on the part of several surgeons. It has been followed by both successes and failures. The cause of failure may be anatomical, since the segments are sometimes so widely separated that they cannot be brought together for anastomosis. Probably the greatest hazard is the supervention of bronchopneumonia from aspiration of food.

In a subsequent report by Haight (4) a total of 16 attempts at direct anastomosis are described, with 6 or 37.5 per cent of the patients alive, with a patent esophagus. Lam (5) in a paper shortly to be published presents 2 cases in which direct anastomosis was done, and both patients are living and well. Of 2 other patients more recently treated by Lam, one is living and able to take food naturally.

This then is the story of a condition that has been considered by most clinicians as incompatible with life and as incurable. The successes reported are the result of a perfected surgical technic and represent another advance in the brilliant history of surgery. In this achievement the clinician and roentgenologist may claim a share, as the early recognition and demonstration of the lesion are essential to surgical success.

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BRONZE STAR AWARDED TO LIEUTENANT COLONEL LEDOUX

Lt. Col. Alfred Campbell Ledoux, of Evanston, Ill., a member of the Radiological Society of North America, has been awarded the Bronze Star Medal for meritorious service as Chief of X-Ray and Radiotherapy Services, 108th General Hospital, European Theatre of Operations, from Sept. 1, 1944, to May 8, 1945. The citation reads: "Lieutenant Colonel Ledoux was chiefly instrumental in the discovery, reconstitution and speedy adaptation of captured x-ray and radiotherapy equipment. This accomplishment was the direct result of his initiative, specialized technical knowledge, linguistic aptitude, and high professional attainments. The immediate availability of such splendid equipment at a time when transportation of our own material was extremely difficult and uncertain, due to the exigencies of the military situation, materially assisted in the diagnostic care and treatment of many thousands of casualties and made the contribution of Lieutenant Colonel Ledoux of immeasurable value."

CANCER TEACHING DAYS

Four Cancer Teaching Days will be observed in New York in October, under joint state and county auspices. The first will be held in Oneonta, Otsego County, on Oct. 3, at the Homer Folks Tuberculosis Hospital. Preceding the formal sessions there will be a Clinical Demonstration and Discussion of Patients by Dr. Wm. A. Milner of Albany Medical College and Drs. Fred W. Stewart, Norman Treves, and Gray H. Twombly, all of Memorial Hospital, New York City. At the afternoon session, at 4 o'clock, Dr. Twombly will speak on "Ovarian Carcinoma" and Dr. Treves on "Cancer of the Breast." In the evening the speakers will be Dr. Milner, on "Carcinoma of the Bladder," and Dr. Stewart on "Biopsy in Tumors."

On Oct. 9, a single session will be held in Rochester at the Academy of Medicine, at 8 P.M. The speakers will be Dr. John H. Garlock, of Mt. Sinai Hospital, New York City, on "Carcinoma of the Colon," and Dr. John J. Morton, Jr., of the University of Rochester School of Medicine and Dentistry, on "Progress in Cancer Research."

On Oct. 17, meetings will be held in Kingston, Ulster County, in the Governor Clinton Hotel, at 3:30 and 7:30. In the afternoon, Dr. Earle D. Osborne, of the University of Buffalo School of Medicine, will discuss "Cancer of the Skin and Allied Tumors," and Dr. Frederick S. Wetherell, of Syracuse University College of Medicine, "The Role of the Practising Physician in the Care of Cancer." The evening speakers will be Dr. Chas. B. Huggins, of the University of Illinois, on "Cancer of the Prostate" and Dr. Fred Stewart on "Biopsy in Tumors."

At Albany, the sessions will be held in the Albany College of Pharmacy, on Oct. 18. At the 3:30 meeting Dr. Hayes Martin of Memorial Hospital, New York City, and Dr. Chas. B. Huggins will be the speakers, their subjects being, respectively, "Cancer of the Head and Neck" and "Cancer of the Prostate." In the evening Dr. George T. Pack, of Memorial Hospital, will speak on "Cancer of the Stomach" and Dr. Clyde L. Randall, of the University of Buffalo School of Medicine, on "Hormone Therapy and the Prevention of Gynecologic Malignancies."

Dinner reservations for the Oneonta, Kingston, and Albany meetings should be sent in advance to Ralph Horton, M.D., Homer Folks Tuberculosis Hospital, Oneonta; Frederick H. Voss, M.D., 69 Spring St., Kingston; Arthur F. Holding, M.D., 142 Washington Ave., Albany 6.

In Memoriam

ISAAC LEVIN, M.D.

1866–1945

Dr. Isaac Levin, well known as a radiologist and for his interest in cancer research, died at the age of 78 on June 19. Dr. Levin was born in Russia, in 1866. He received his medical education there and served as attending surgeon in the Army Hospital in St. Petersburg before emigrating to America. He was an associate in pathology at Columbia University, New York, from 1909 to 1912 and associate in cancer research in that university from 1912 to 1915. He was clinical professor of cancer research in the University and Bellevue Hospital Medical College for many years and was at one time chief of the cancer division of Montefiore Hospital. From 1923 to 1930 he was director of the New York City Cancer Institute. He was consultant radiologist at Lebanon Hospital.

Dr. Levin was a diplomate of the American Board of Radiology and held membership in many scientific societies, including the Radiological Society of North America, American College of Radiology, Society for Experimental Biology and Medicine, the American Association of Pathologists and Bacteriologists, Harvey Society, American Physiological Society, American Genetic Association, American Association for Cancer Research, and American Radium Society.

Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be [illegible]

shed in the interest of our readers and as space ermits.

UBLICACIONES DEL CENTRO DE INVESTIGACIONES TISIOLOGICAS. Director: Prof. Roque A. Izzo. Volume VIII. Pabellon "Las Provincias," Hospital Tornú, Buenos Aires, 1944.

Book Reviews

IOULDER LESIONS. By H. F. MOSELEY, M.A., D.M., M.Ch., Assistant Surgeon, Royal Victoria Hospital, Montreal. A volume of 181 pages, with 71 illustrations. Published by Charles C Thomas, Springfield, Ill., 1945.

So much progress has taken place since the monuental work of Codman on the shoulder that this ort and concise monograph should be welcome, as presents an excellent discussion of our present iowledge of the subject. The author discusses the e of local infiltration of procain as a therapeutic id diagnostic aid, emphasizing its great value. He of the opinion that novocaine injection can restore ll movement and power in an injured or painful oulder in spite of the presence of a complete rupre of the supraspinatus tendon. The return of full nction after injection is considered to be accommied by an excellent prognosis. This belief that ll movement can occur in the presence of a torn usculo-tendinous cuff is somewhat in disagreement ith the writings of many authorities.

Bicipital syndromes are described as tendinitis id tenosynovitis, partial and complete rupture of ie tendon and recurrent subluxations of the tendon. he importance of these lesions and their role in the rly stages of a frozen shoulder are well described. There are interesting chapters on the neurological aspects of shoulder pain by McNaughton, and one on roentgen diagnosis and treatment by Bouchard and Peirce. Other chapters deal with examination and kinesiology of the shoulder, rupture of the rotator cuff, subluxation and dislocation, periarthritis, and operative approaches and procedures.

The writer summarizes the pathology of dislocation as follows: In simple dislocation the morbid anatomy is a tear of the capsule and subscapularis tendon from the neck of the humerus, which eventually heals. In true recurrent dislocating shoulder the initial dislocation results in a tearing of the capsule in the antero-inferior area of the glenoid rim or humeral neck. This fails to heal back completely, due to a second injury a short period later, followed by repeated stretching and failure of fibrocartilage to heal. With these changes is associated a weakening of the muscles around the shoulder due to disuse. This disuse is due to the tendency to treat dislocated shoulders after reduction in a sling for varying periods, from two to four weeks, without any attempt at re-education of those muscles in movements or power. Thus, the main strength of the shoulder joint is lost, with a tendency to dislocate with less force than was previously required. By a correlation of the pathology, mechanism, and treatment, the writer draws the conclusion that the Bankart procedure or plastic repair of the anterior capsule in cases of torn subscapularis tendon should replace all others in the therapy of recurrent dislocations of the shoulder.

Of considerable value is the strong emphasis which is placed upon the role of weak and atrophic muscles in the clinical picture which follows shoulder injuries. There is a careful description of the technics of re-education and the active use of voluntary movements, which should lead to the creation of a powerful musculature and therefore to shoulder stability.

Editor's Note.—Will secretaries of societies please cooperate by sending information to Howard P. Doub, M.D., Editor, Henry Ford Hospital, Detroit 2, Mich.

UNITED STATES

Radiological Society of North America.—Secretary, D. S. Childs, M.D., 607 Medical Arts Bldg., Syracuse 2, N.Y.

American Roentgen Ray Society.—Secretary, Harold Dabney Kerr, M.D., Iowa City, Iowa.

American College of Radiology.—Secretary, Mac F. Cahal, 20 N. Wacker Dr., Chicago 6, Ill.

Section on Radiology, American Medical Association.—Secretary, U. V. Portmann, M.D., Cleveland Clinic, Cleveland 6, Ohio.

ARKANSAS

Arkansas Radiological Society.—Secretary, J. S. Wilson, M.D., Monticello. Meets every three months and annually at meeting of State Medical Society.

CALIFORNIA

California Medical Association, Section on Radiology.—Secretary, Gordon King, M.D., Children's Hospital, San Francisco.

Los Angeles County Medical Association, Radiological Section.—Secretary, Roy W. Johnson, M.D., 1407 South Hope St., Los Angeles. Meets second Wednesday of each month at County Society Building.

Pacific Roentgen Society.—Acting Secretary, Frederick H. Rodenbaugh, M.D., 490 Post St., San Francisco. Meets annually with California Medical Association.

San Diego Roentgen Society.—Secretary, Henry L. Jaffe, M.D., U. S. Naval Hospital, San Diego, Calif. Meets first Wednesday of each month.

San Francisco Radiological Society.—Secretary, Carlton L. Ould, University Hospital, Medical Center, San Francisco 22. Meets monthly on the third Thursday at 7:45 P.M., first six months of the year in Lane Hall, Stanford University Hospital, and second six months in Toland Hall, University of California Hospital.

COLORADO

Denver Radiological Club.—Secretary, A. Page Jackson, Jr., M.D., 304 Republic Bldg., Denver 2. Meetings third Friday of each month, Denver Athletic Club.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Secretary, Max Climan, M.D., 242 Trumbull St., Hartford 3. Meetings bimonthly, second Thursday.

FLORIDA

Florida Radiological Society.—Secretary-Treasurer, J. F. Pitman, M.D., Blanche Hotel Annex, Lake City.

GEORGIA

Georgia Radiological Society.—Secretary-Treasurer, James J. Clark, M.D., 478 Peachtree St., N. E., Atlanta 3. Meets in November and at the annual meeting of State Medical Association.

ILLINOIS

Chicago Roentgen Society.—Secretary, Fay H. Squire, M.D., 1753 W. Congress St., Chicago 12. Meets at the Palmer House, second Thursday of October, November, January, February, March, and April.

Illinois Radiological Society.—Secretary-Treasurer, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology—Secretary, Frank S. Hussey, M.D., 250 East Superior St., Chicago 11.

INDIANA

The Indiana Roentgen Society.—Secretary-Treasurer, Harold C. Ochsner, M.D., Methodist Hospital, Indianapolis 7. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Secretary, Arthur W. Erskine, M.D., Suite 326 Higley Building, Cedar Rapids. Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—Secretary-Treasurer, Sydney E. Johnson, 101 W. Chestnut St., Louisville.

LOUISIANA

Louisiana Radiological Society.—Secretary-Treasurer, Johnson R. Anderson, M.D., North Louisiana Sanitarium, Shreveport. Meets annually at same time as State Medical Society.

Shreveport Radiological Club.—Secretary, Oscar O. Jones, M.D., 2622 Greenwood Road. Meets monthly September to May, third Wednesday, 7:30 P.M.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Secretary, Charles N. Davidson, M.D., 101 West Read St., Baltimore 1.

MICHIGAN

Detroit X-ray and Radium Society.—Secretary-Treasurer, E. R. Witwer, M.D., Harper Hospital, Detroit 1. Meetings first Thursday of each month from October to May, at Wayne County Medical Society club rooms.

Michigan Association of Roentgenologists.—Secretary, Bruce MacDuff, M.D., 201 Sherman Bldg., Flint 3.

MINNESOTA

Minnesota Radiological Society.—Secretary, A. T. Stenstrom, M.D., Minneapolis General Hospital, Minneapolis 26. Meetings quarterly.

MISSOURI

Radiological Society of Greater Kansas City.—Secretary, John W. Walker, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Friday of each month.

St. Louis Society of Radiologists.—Secretary, Edwin C. Ernst, M.D., 100 Beaumont Medical Bldg. Meets on fourth Wednesday of each month except June, July, August, and September.

NEBRASKA

Nebraska Radiological Society.—Secretary-Treasurer, Donald H. Breit, M.D., University of Nebraska Hospital, Omaha 5. Meetings third Wednesday of each month at 6 P.M. in either Omaha or Lincoln.

NEW ENGLAND

New England Roentgen Ray Society.—Secretary-Treasurer, George Levene, M.D., Massachusetts Memorial Hos-

itals, Boston, Mass. Meets monthly on third Friday : Boston Medical Library.

NEW HAMPSHIRE

ew Hampshire Roentgen Society.—Secretary-Treasurer, ichard C. Batt, M.D., St. Louis Hospital, Berlin.

NEW JERSEY

idiological Society of New Jersey.—Secretary, H. R. :indle, M.D., 501 Grand Ave., Asbury Park. Meetgs at Atlantic City at time of State Medical Society d midwinter in Newark as called.

NEW YORK

ssociated Radiologists of New York, Inc.—Secretary, 'illiam J. Francis, M.D., East Rockaway, L. I.

rooklyn Roentgen Ray Society.—Secretary-Treasurer, :o A. Harrington, M.D., 880 Ocean Ave., Brooklyn 26. :eets fourth Tuesday of every month, October to April.

uffalo Radiological Society.—Secretary-Treasurer, oseph S. Gian Franceschi, M.D., 610 Niagara St., uffalo 1. Meetings second Monday evening each onth, October to May, inclusive.

entral New York Roentgen Society.—Secretary-Treasurer, arlton F. Potter, M.D., 425 Waverly Ave., Syracuse). Meetings in January, May, and October.

ong Island Radiological Society.—Secretary, Marcus 'iener, M.D., 1430 48th St., Brooklyn 19. Meetings urth Thursday evening each month at Kings County :edical Bldg.

ew York Roentgen Society.—Secretary, Wm. Snow, I.D., 941 Park Ave., New York 28.

ochester Roentgen-Ray Society.—Secretary, Murray P. eorge, M.D., 260 Crittenden Blvd., Rochester 7. leets at Strong Memorial Hospital, third Monday, :ptember through May.

NORTH CAROLINA

adiological Society of North Carolina.—Secretary-reasurer, Major I. Fleming, M.D., 404 Falls Road, ocky Mount. Meets in May, and October.

NORTH DAKOTA

orth Dakota Radiological Society.—Secretary, Charles eilman, M.D., 1338 Second St., N., Fargo.

OHIO

hio Radiological Society.—Secretary, Henry Snow, I.D., 1061 Reibold Bldg., Dayton 2. Next meeting at nnual meeting of the Ohio State Medical Association.

leveland Radiological Society.—Secretary-Treasurer, lon D. Brannan, M.D., 11311 Shaker Blvd., Cleveland . Meetings at 6:30 P.M. on fourth Monday of each onth from October to April, inclusive.

adiological Society of the Academy of Medicine (Cinnnati Roentgenologists).—*Secretary-Treasurer,* Samel Brown, M.D., 707 Race St., Cincinnati 2. Meetgs held third Tuesday of each month.

PENNSYLVANIA

ennsylvania Radiological Society.—Secretary-Treasurer, . E. Wurster, M.D., 416 Pine St., Williamsport 8. he Society meets annually.

hiladelphia Roentgen Ray Society.—Secretary, Calvin . Stewart, M.D., Jefferson Hospital, Philadelphia 7. leets first Thursday of each month at 8:00 P.M., from ctober to May, in Thomson Hall, College of Physiians, 21 S. 22d St.

Pittsburgh Roentgen Society.—Secretary-Treasurer, Lester M. J. Freedman, M.D., 4800 Friendship Ave., Pittsburgh 24. Meets second Wednesday of each month at 6:30 P.M., October to May, inclusive, at The Ruskin, 120 Ruskin Ave.

ROCKY MOUNTAIN STATES

Rocky Mountain Radiological Society (North Dakota, South Dakota, Nebraska, Kansas, Texas, Wyoming, Montana, Colorado, Idaho, Utah, New Mexico).—*Secretary,* A. M. Popma, M.D., 220 North First St., Boise, Idaho.

SOUTH CAROLINA

South Carolina X-ray Society.—Secretary-Treasurer, Robert B. Taft, M.D., 103 Rutledge Ave., Charleston 16.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—Secretary-Treasurer, J. Marsh Frère, M.D., 707 Walnut St., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Dallas-Fort Worth Roentgen Study Club.—Secretary, X. R. Hyde, M.D., Medical Arts Bldg., Fort Worth, Texas. Meetings on third Monday of each month, in Dallas in the odd months and in Fort Worth in the even months.

Texas Radiological Society.—Secretary-Treasurer, Asa E. Seeds, M.D., Baylor Hospital, Dallas.

VIRGINIA

Virginia Radiological Society.—Secretary, E. Latané Flanagan, M.D., 215 Medical Arts Bldg., Richmond 19.

WASHINGTON

Washington State Radiological Society.—Secretary-Treasurer, Thomas Carlile, M.D., 1115 Terry Ave., Seattle. Meetings fourth Monday of each month, October through May, at College Club, Seattle.

WISCONSIN

Milwaukee Roentgen Ray Society.—Secretary-Treasurer, C. A. H. Fortier, M.D., 231 W. Wisconsin Ave., Milwaukee 3. Meets monthly on second Monday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, S. R. Beatty, M.D., 185 Hazel St., Oshkosh. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 414 N. Charter St., Madison 6. Meets first and third Thursdays, 4 to 5 P.M., September to May, inclusive, Room 301, Service Memorial Institute.

CANADA

Canadian Association of Radiologists.—Honorary Secretary-Treasurer, J. W. McKay, M.D., 1620 Cedar Ave., Montreal.

La Société Canadienne-Française d'Electrologie et de Radiologie Médicales.—General Secretary, Origène Dufresne, M.D., Institut du Radium, Montreal. Meets on third Saturday of each month.

CUBA

Sociedad de Radiología y Fisioterapia de Cuba.—Offices in Hospital Mercedes, Havana. Meets monthly.

ROENTGEN DIAGNOSIS

The Head and Neck

The Chest

The Digestive System

The Skeletal System

Gynecology and Obstetrics

THE HEAD AND NECK

Platybasia and Occipital Vertebra Causing Foramen Magnum Encroachment and Resulting Neurologic Symptoms. Lee A. Hadley. New York State J. Med. 44: 2355–2357, Nov. 1, 1944.

Constriction of the foramen magnum, with neurologic manifestations, may be caused either by platybasia or by so-called occipital vertebra. A case of the latter type is presented.

Occipital vertebra results from incomplete assimilation of the most posterior of the three embryologic cervical segments or scleromeres which form the base of the skull, *i.e.*, the area about the foramen magnum assumes certain features resembling a vertebral segment. (1) There is a hypochordal arch, partially or completely fused to the anterior margin of the foramen magnum, and (2) a partial or complete neural arch outlined about the dorsal surface of the foramen. (3) Transverse processes, more or less fused to the base of the skull may or may not be present. If present, they do not bear a foramen for the vertebral artery. (4) These masses, bearing the condyles, may or may not encroach upon the foramen, distorting its shape. (5) The condyles resemble those of the normal subject. (6) The so-called third condyle, ossiculum terminale, may be present in the anterior portion of the foramen. This is a separate ossification developed from the notochord in the terminal ligament of the odontoid and may embryologically in the normal subject form the tip of that structure. Analogous to the relationship between the atlas and the dens, the third condyle corresponds to the body of the occipital vertebra with the hypochordal arch in front and the neural arch behind.

In the case of occipital vertebra recorded here, roentgenograms showed a normal atlas and a broad, short odontoid process. The posterior margin of the foramen magnum was thinned and below normal level. At operation this was found to bear, somewhat laterally, two cornua—indicating a rudimentary, incomplete neural arch. The outline of the foramen magnum was shaped like a bicycle seat, as the result of two bony masses projecting from the sides of the foramen and encroaching upon its anterior portion. The ossiculum terminale appeared within this narrowed portion as a distinct oval-shaped ossicle entirely separate from the odontoid.

Eosinophilic Granuloma of the Skull. John Raaf. West. J. Surg. 53: 1–4, January 1945.

A case of eosinophilic granuloma in a six-months-old boy is presented. The lesions, which affected the skull and right fibula, healed rapidly following curettement. After more than a year neither lesion had recurred and no new ones had developed. Preoperative and follow-up roentgenograms of the skull and fibula are reproduced.

Diagnosis of Mandibular Joint Neuralgia and Its Place in General Head Pain. James B. Costen. Ann. Otol., Rhin. & Laryng. 53: 655–659, December 1944.

Mandibular joint neuralgia embraces some or all of the usual distributions of fifth nerve pain. It belongs in the reflex or secondary group of neuralgias, in which mechanical irritation of branches reflects pain to standard cranial areas.

Any regularly recurring facial pain associated with movement of the lower jaw allows the possible diagnosis of mandibular joint neuralgia, until such condition is definitely ruled out. The author has previously reported a case (Arch. Otolaryng. 36: 553, 1942) due to fracture or separation of bone of the tympanic plate, proved by roentgen study and by the relief attained from fixing the lower jaw with a strong elastic headband.

The anatomy of the attachment of the mandible to the skull provides obvious chances for impingement of the condyle on sensory nerve branches. Mesially, it may irritate the chorda tympani nerve as it passes out of the glenoid fossa through the petro-tympanic fissure. Posteriorly it may produce impaction of the auricular branches of the auriculotemporal nerve within the temporomandibular articulation, and with wider, loose movement, the condyle may irritate the auriculotemporal nerve itself. When sufficient destruction of joint structures occurs to allow the eroded face of the condyle to rest against the tubercle of the glenoid fossa, an abundant source of reflex pain is produced.

The diagnosis of mandibular joint neuralgia depends upon the history, gross findings, roentgen study, and the test of treatment. There may be a history of some incident producing acute trismus and mandibular joint injury or, again, of some long-standing condition with varying grades of chronic trismus. In the latter event, the early symptoms follow no pattern, and there is no fixed rule as to severity. Although complete loss of the molar teeth invites destruction of the mandibular joints, this does not invariably follow.

The author's concise presentation of the other diagnostic features may well be repeated here.

Gross Findings

- Unilateral or bilateral loss of molar teeth
- Overclosure on maloccluding natural teeth, or ill-fitting dental plates
- Uneven movement of the lower jaw on opening and closing
- Crepitus within the mandibular joints
- Tenderness of the mandibular joints to internal palpation
- Presence of trismus, all grades

Roentgenological Findings

- Density changes in the mandibular joint structures
- Narrowing of spaces between the condyle and glenoid fossa, either uniform or asymmetric
- Widening of joint spaces and wide excursion of the condyles in the open position
- Fixation of one condyle against the tubercle and normal excursion of the opposite condyle
- Erosion of the anterior surface of the condyle and posterior aspect of the articular tubercle
- Change in normal contour of glenoid fossa (deepening) and of the condyle, but with normal bone surfaces (suggestive of abnormal stress)
- Fracture of the tympanic plate
- Impacted unerupted third molar teeth

Test of Treatment

- Observation of pain changes after fixation of the lower jaw with elastic headgear

Decrease or increase of pain after slight change in closed position of the condyle and fixation with elastic headgear (using cork disks of accurate thickness or, better, temporary dental appliques)
Removal of abscessed teeth, impacted teeth, and correction of all sources of trismus
Dental reconstruction to correct condylar malpositions. STEPHEN N. TAGER, M.D.

Fibrosarcoma of the Larynx. John H. Foster. Ann. Otol., Rhin. & Laryng. 53: 764–769, December 1944.

A 31-year-old man had a subglottic tumor diagnosed by indirect laryngoscopy and shown roentgenographically to extend into the lumen of the trachea. The mass measured 2 cm. in diameter and appeared to arise from a broad base on the anterior portion of the trachea just distal to the larynx. It was sharply circumscribed, having a somewhat irregular summit, containing no calcifications. The lumen of the trachea was considerably narrowed. The lungs showed normal aeration, with no evidence of infiltration or consolidation. Other chest findings were normal. Bits of tissue, from the size of a pea to that of an almond, had been coughed up on several occasions, and microscopic examination of one of these showed fibrosarcoma.

The tumor was exposed by direct laryngoscopy and found to be attached to the anterior wall in the region of the cricoid isthmus. The greater part was removed with a snare. The patient suffered very little reaction, and relief of dyspnea was complete. Three days later the application of a radium pack to the neck over the site of the tumor was begun, 50 mg. of radium being applied for fourteen hours on three successive nights. Healing was uneventful, and at the time of the report, six months later, there was no sign of recurrence.

STEPHEN N. TAGER, M.D.

THE CHEST

Wounds of the Chest in Pacific Jungle Warfare: Review of Thirty-Two Cases. Harry G. Hardt, Jr. Arch. Surg. 49: 367–372, December 1944.

The course and results of penetrating chest wounds are influenced by three factors: (1) the character and course of the penetrating missile; (2) the physical condition of the soldier when wounded; (3) the promptness of first aid and transportation to facilities for adequate care. In the series of 32 cases recorded here, the patients were all in the same general physical condition and all had early and efficient treatment by the same medical organization. The character of the missile was the only variable factor. The weapons used and, therefore, the wounds inflicted are considered typical of Pacific jungle warfare.

The most commonly seen wound was caused by fragments of Japanese 50-mm. mortar shells. Such wounds were present in 12 of the 32 cases reported. On detonation this shell disintegrates into many small fragments, producing a large irregular wound with numerous small penetrations at the base if the shell bursts in close proximity or multiple small perforations if it bursts at a distance. The roentgenogram resembles that of a shotgun wound with irregular shot of various sizes. The Japanese hand grenade causes similar wounds, except that no strips of metal (fragments of the detonator) are found. Four men were wounded by large-caliber artillery shells; these caused large jagged wounds with extensive surrounding areas of damage. The foreign bodies were large and irregular and usually lodged in the wound. No knife, bayonet, or case shot shrapnel wounds were seen.

The presence of an obliterated pleural cavity, resulting from previous pleural disease, may cause bleeding to take place into the pulmonary parenchyma. This leads to clouding of the pulmonary field roentgenologically, with later clearing as the blood is expectorated.

In 9 cases in this series the wounds were perforating, in 23 penetrating. The wound was in a "safe area" of the chest with a single exception, in which the heart muscle was injured. In only 6 cases was shock severe; routine prophylactic administration of plasma was thought to have contributed to this low incidence. Hemoptysis was observed in 19 patients, dyspnea in 29, hemothorax in 26, pneumothorax in 10, rib fractures in 10, fractures of the scapula in 3, of the spine in 3, and of the sternum and clavicle in 1 each. Complications included a bronchopleural fistula, 3 infected hemothoraces, and 2 cases of secondary pneumonitis. No deaths occurred at the author's hospital, but 2 men with severed spinal cords were transferred and considered to have a bad prognosis. All patients were evacuated by air, with no untoward effects.

Treatment consists of application of sulfanilamide crystals locally, exploration, and débridement. Primary closure was accomplished in 14 men, the wound was packed open in 11, and in 7 the damage was so slight as to require only cleansing and a dressing. In 1 case a secondary operation for continued hemorrhage was needed, and 3 men required drainage of an empyema. Hemothorax was not treated if asymptomatic; in the presence of symptoms aspiration and replacement with air are recommended in cases seen within three days; simple aspiration otherwise. Persistent unexplained fever and dyspnea are considered indications for intervention.

LEWIS G. JACOBS, M.D.

The Chest X-Ray. Dan G. Morse. Dis. of Chest 10: 515–527, November–December 1944.

A statistical study of 223,182 chest roentgenograms is presented. Most of the material consisted of Selective Service registrants between the ages of eighteen and thirty-five, of whom 47 per cent were colored. The examinations were made with 4 × 5-in. film, stereoscopically, and subjects with suspicious findings were re-examined with 14 × 17-in. film. Many conditions were found, resulting in 1,801 permanent and 495 temporary rejections.

The incidence of disabling diseases of the chest was 1.018 per cent, but that of active tuberculosis only 0.3284 per cent. Most of the cases of tuberculosis were early and treatable, demonstrating the value of mass surveys. Only 12.7 per cent of a group with rejectable chest disease showed significant physical findings, and only 14 out of every 100 cases of active tuberculosis could have been suspected from physical examination alone. Thirty-six examples of true dextrocardia were discovered, an incidence of 0.16 per cent, or 1 in 6,200. One in every 140 examined had a congenital rib anomaly. There were 452 examples of cervical rib, in none of which were symptoms present. Foreign bodies were another interesting finding. Five men had portions of knife blades in the chest; 4 of these were unaware of the presence of the foreign body and the fifth complained only of occasional vague pain. Shotgun

pellets were discovered in 40 cases and a sewing needle in 1. A triangular area of opacity believed to be due to a piece of auto glass was present in another.

HENRY K. TAYLOR, M.D.

Role of the Roentgenogram in Tuberculosis Finding. Arthur Rest. Rocky Mountain M. J. 41: 906–910, December 1944.

This article reports a study of 39 persons between the ages of eighteen and forty-two who were entirely unaware that they had active pulmonary tuberculosis until it was revealed by x-ray examination incident to Army induction or a mass survey. In only 4 of the 39 cases was contact given as a probable source of infection.

Eight patients had minimal lesions, 14 moderately advanced, and 17 far advanced disease. The sputum was positive in 4 of the minimal and in 10 of the moderately advanced cases. Twenty patients denied any symptoms of active tuberculosis or a persistent respiratory infection prior to examination. Among the others, the most common complaint was a slight, persistent, productive cough, attributed in some cases to smoking.

The author considers this group of 39 cases of active pulmonary tuberculosis to be representative of a small percentage of similar undiagnosed cases which would be readily revealed by routine x-ray examination of the chest.

PERCY J. DELANO, M.D.

Tuberculosis Among Medical School Personnel at the University of Texas from 1941 to 1944. Jesse B. Johnson and W. S. Wallace. Texas State J. Med. 40: 428–432, December 1944.

The prevalence among medical students, nurses, and other hospital personnel of pulmonary tuberculosis was revealed by incidences as high as 10 per cent reported from the Harvard Medical School in 1924 and 11.5 per cent from the University of Pennsylvania Medical College in 1930. Subsequently, the incidence of tuberculosis in medical students has been shown to average somewhere around 0.5 per cent, as compared to 0.1 per cent in other college students (Tuberculosis Committee, American Student Health Association, Tenth Annual Report. Journal-Lancet 61: 115, 1941). Significantly enough, in every available report the introduction of routine annual chest roentgenography for the student body increased the number of cases found by 400 per cent or more.

At the University of Texas Medical School routine chest surveys were begun in February 1941. In that year 2.93 per cent of medical students and 4.16 per cent of student nurses were found to have tuberculosis. In 1942 the incidence was 2.13 per cent for medical students and 0.83 per cent for student nurses. In 1943 the incidence was 1.33 for the student body, while no cases among student nurses were discovered. In 1944 the incidence dropped to 1.06 per cent for the student body. Again no cases were discovered in student nurses. One case yearly was found among faculty members, with the exception of 1942, during which year two cases were discovered.

The explosive development of pulmonary tuberculosis within six months in previously x-ray negative students and the relative ease of survey examination have prompted the authors to adopt a program of four yearly chest examinations for students, two yearly chest examinations for nurses, and one yearly examination for all other Medical Branch personnel.

ELLWOOD W. GODFREY, M.D.

Tuberculosis in West Virginia Industries. J. T. Duncan and C. Scott McKinley. West Virginia M. J. 40: 373–378, December 1944.

From the standpoint of the long-term tuberculosis program, industrial surveys constitute an excellent case-finding procedure because of the high incidence of tuberculosis among workers of relatively low economic status. Under the war-production program, great numbers of migrant laborers are working long hours and living under excessively crowded conditions; the number of woman employees between twenty and thirty-five, an age group showing a high incidence of tuberculosis, is increased; and other potentially dangerous factors are operative to enhance the susceptibility to tuberculosis among certain groups and to increase the intensity and duration of contact with the disease. Now is the time, during the lag period before the threatened increase in incidence occurs, to set in motion a case-finding and control program in industry.

Surveys were made in four war-industry plants (two large and two of medium size) with a total labor force of approximately 7,600. Of this number, 86 per cent were examined roentgenographically; 4 × 5-inch photoroentgenograms were used and all positive and doubtful cases (8.5 per cent of the total) were restudied with 14 × 17-in. films. Cases of tuberculosis and other conditions found during the surveys were reported to the medical director of the plant (when there was no director, to the patient's physician) and to the county health department.

The incidence of tuberculosis among those examined was 1.4 per cent and of active cases 0.58 per cent. These figures are lower than those—7.0 per cent and 1.3 per cent—obtained in a survey of the furriers' union in New York City several years ago. More recent surveys of 125,000 workers in eleven states, by the U. S. Public Health Service, have revealed a 1.3 per cent incidence, which agrees better with the figures obtained in this series of examinations

In addition to the number of definite cases of tuberculosis, 1.3 per cent of the total were regarded as "suspects," while 7.6 per cent were found to have definite or suspected abnormalities of the cardiac or aortic silhouette.

Of the total cases of tuberculosis, 67 per cent were minimal, 28 per cent moderately advanced, and 4 per cent far advanced. Of the minimal cases, 40 per cent were regarded as active or questionably active; 34 per cent of the moderately advanced cases were active and, of course, 100 per cent of the far advanced cases. The majority of active cases occurred in the age group twenty-five to forty-four years, which, of course, includes a vast majority of men in industry. The rate of incidence, however, increased with age, being highest among those over forty-five.

The employment and the type of work a tuberculous patient should do can be classified according to activity and degree of pulmonary involvement. No person with an active lesion should be employed, but patients with arrested or quiescent lesions of moderate extent may engage in moderate physical work, and those with healed and stable lesions may be allowed more vigorous activity.

Anyone with a suspicious pulmonary lesion should undergo periodic examination in order that a final diagnosis may be reached. In the arrested case, frequent check-ups are indicated. When the patient first returns to work a monthly check-up should be insisted upon, including temperature, weight, blood count, and

ray examination and a sedimentation test if practical. e interval between examinations can be increased time elapses, but should never exceed a year.

J. E. WHITELEATHER, M.D.

ower Lung Field Tuberculosis. Samuel S. Romen-k, Bernard Friedman, and Herbert F. Schwartz. of Chest 10: 481–488, November–December 1944.

he authors studied the roentgenograms of 2,354 con-utive patients with pulmonary tuberculosis dis-rged from the Robert Koch Hospital (St. Louis) from ruary 1933 to February 1942. Excluded from this dy were upper lobe lesions and primary infections; cases of bronchiectasis and pleural effusion or pleural ckening unless a parenchymal tuberculous lesion was present. Sixty-three examples of lower lung field erculosis were found, an incidence of 2.7 per cent; cases were in females and 19 in males; 43 patients re white and 20 Negroes. The ages ranged from een to fifty-eight, with 49 patients (91.5 per cent) der forty. Among the Negroes, 90 per cent were der thirty; the oldest Negro was thirty-three years age. There were 37 instances of right-side and 26 of -side involvement; 24 patients had moderately ad-nced and 39 far advanced lesions. In onset, symp-ns, duration, pathology, and prognosis, the disease fered in no way from the usual form of pulmonary erculosis.

HENRY K. TAYLOR, M.D.

Closure of Tuberculous Cavities. John Loesch. Rev. Tuberc. 50: 500–519, December 1944.

Anatomical observations and studies on the mecha-m of closure of tuberculous cavities have been infre-ent. The available evidence has indicated that ities may heal in different ways, but the relative quency of each mechanism is unknown. In order throw more light on this subject, the author reports detailed study of complete closure of cavities in 5 ients, 4 of whom had been treated with pneumotho-and one with strict bed rest. A sixth example, a ca-y which had shrunk markedly under strict bed rest, is luded as a transitional case. All patients were closely died roentgenographically and all had postmortem mination.

n general, factors which influence the closure of ities are: location, duration, thickness of the cavity ll, size, caliber and number of draining bronchi, and ssibly, also, the allergic state of the cavity tissue. e mechanism at work in the cases studied was for the st part one of shrinkage of the cavity with simultane-s contraction, approximation, and final obliteration of the cavity outlet or (2) of the tuberculous bron-us at the point of transition into the normal portion fibrotic tissue, or (3) at both these points when case-s material was retained in the diseased bronchial rtion between them. After closure at these points cavities shrank further and the content retained in em became inspissated and finally partially calcified.

L. W. PAUL, M.D.

Healed Asymptomatic Miliary Tuberculosis. Karl E. ssowitz. J. Pediat. 26: 56–60, January 1945.

The roentgenogram of an 8-year-old boy with a posi-e tuberculin reaction, normal hemogram and sedi-ntation rate showed a healed primary tuberculosis. o years later a routine roentgenogram of the chest this patient, who in the meantime had been attend-school regularly, revealed an evenly distributed, healed, calcified miliary tuberculosis. The general physical condition, hemogram, and sedimentation rate were normal. A guinea-pig, inoculated with stomach washings, showed no evidence of tuberculosis. The patient's health, as well as all clinical tests, continued normal for the next three years. At the end of that time x-ray examination showed identical evidence of miliary tuberculosis.

This report adds to the evidence in the literature that hematogenous dissemination and possibly even lympho-genous or bronchogenic spread of tuberculosis may, in rare instances, be unaccompanied by clinical manifes-tations.

Aetiology of Erythema Nodosum. C. Bruce Perry. British M. J. 2: 843–847, Dec. 30, 1944.

In order to throw further light on the etiology of ery-thema nodosum, the author studied a series of 112 cases (38 in males, 74 in females). Under fifteen years of age there were 36 boys and 31 girls, whereas over this age there were 43 females and only 2 males. Of the 112 patients, 61 gave a strongly positive Mantoux reaction and 51 a negative reaction to 0.01 mg. of tuberculin. In 21 of the 61 patients with a positive reaction the roentgenograms showed enlarged hilar shadows on one side; some of these showed also a shadow of the pri-mary lesion, and others a picture similar to that of epituberculosis. One patient had a typical tuberculous cervical adenitis, and one died later of tuberculous peritonitis. In 4 cases a pleural effusion subsequently developed; in 2 of these the roentgen picture was nor-mal at the time of the eruption. A 2-year-old boy with a positive tuberculin reaction but no roentgen evidence of disease subsequently had miliary tuberculosis and died of tuberculous meningitis. Altogether, of the series of 112 patients, 32 (28 per cent) were considered definitely tuberculous, 28 (25 per cent) were probably tuberculous, and 51 (45 per cent) were definitely not tuberculous. Of the 67 patients under the age of fifteen, 29 (43 per cent) were definitely tuberculous and 8 (17 per cent) probably tuberculous. Therefore, in 72 per cent of the cases of erythema nodosum in children of school age or under, the eruption probably marked the development of primary tuberculosis.

Ten of the 112 patients had had acute rheumatism previously; in 4, the heart was normal at the time of the erythema nodosum. In only 2 was there any evi-dence of a rheumatic relapse. In both the rheumatism appeared to follow the erythema nodosum and not to occur simultaneously. This supports the theory that while the two diseases both follow a streptococcal in-fection, they are not necessarily the same. Five pa-tients, including the 2 having a rheumatic relapse, gave negative tuberculin reactions, and 4 of these were sen-sitive to streptococcal nucleoprotein. Of the remaining 5, 2 were certainly tuberculous, as judged by roentgeno-grams and Mantoux tests.

A family history of erythema nodosum was elicited in 10 cases. Eleven patients gave a history of an acute pharyngitis preceding the erythema nodosum. Of these, 4 had had previous attacks, and all but 2 had a nega-tive tuberculin reaction.

These findings agree with those of other workers, indicating that erythema nodosum must be regarded as the result of a non-specific reaction to a variety of in-fectious or toxic agents; that it is not a specific disease and occurs only in patients predisposed to it by their constitutional make-up.

Diagnosis of Bronchiectasis: Clinical and Roentgenological Observations. Mark H. Joress and Samuel A. Robins. Dis. of Chest **10**: 489–508, November–December 1944.

Bronchiectasis is, for the most part, an acquired abnormality of the bronchi. It is found frequently in childhood and young adult life and may follow any of the following conditions: recurrent bronchial infection; chronic lobar and bronchiolar pneumonia; whooping cough complicated by pneumonia; acute or chronic lung abscesses; bronchial obstruction due either to extrinsic or intrinsic lesions, as inflammatory cicatrices, carcinoma, aneurysm, mediastinal or lung tumors; chronic empyema.

Pathologically there are atrophy and destruction of the muscular and elastic tissues of the bronchial wall, leading to dilatation. In long-standing cases there is complete disintegration. In advanced cases the infectious process invades the lung parenchyma, resulting in a bronchopulmonary suppuration. Indirect factors in the development of the disease are pulmonary fibrosis, chronic cough, and lobar atelectasis.

There are four main types: ulcerative, stenotic, fibrotic, and "dry hemorrhagic;" the last is thought to be congenital. Anatomically there are cylindrical, saccular, and occasionally fusiform bronchial dilatations. The mild cases show only slight cough, scanty or moderate sputum with no odor, and no hemorrhage. In advanced cases cough is constant and exhausting and the sputum abundant and foul. Hemorrhages, bronchopneumonia, atelectasis, and empyema may supervene. When atelectasis becomes permanent, the lobe shrinks.

The roentgen findings vary considerably and without the aid of contrast substance the diagnosis is not conclusive. It should be suspected in the presence of prominent bronchial markings, honeycombed radiolucent areas, lobar or lobular atelectasis, areas of mottled density or infiltration, or bronchiectatic cavity with fluid. Bronchography is the diagnostic method of choice. The disease must be differentiated from tuberculosis, a foreign body in the bronchus, bronchial carcinoma, and pulmonary abscess.

The authors analyze a series of 62 cases from military and civilian life and include several illustrative case histories. The condition shows similar characteristics in the two groups. It is believed that the aggregate number of cases of confirmed bronchiectasis in the Armed Forces constitutes a fair proportion of the total number of inductees separated from the service for disability. In a series of 1,753 such separations, 2 per cent were for bronchiectasis.

HENRY K. TAYLOR, M.D.

Spontaneous Pneumothorax: Report of Three Unusual Cases. Alfred Goldman and Harold Roth. Ann. Int. Med. **21**: 1011–1021, December 1944.

The first of the authors' cases, in a man of 51, was a spontaneous pneumothorax in the right chest with cystic disease, presumably congenital, in the right upper lung field, an unusual association in an adult. The removal of 1,000 c.c. of air quickly deflated the pneumothorax, and 15 c.c. of the patient's own blood were injected to produce pleural adhesions and prevent, if possible, a recurrence of the pneumothorax. A rapid clinical cure resulted, and subsequent roentgen study showed complete re-expansion of the lung.

The second case was a left-sided spontaneous pneumothorax with complete atelectasis of the left upper lobe and moderate collapse of the left lower lobe. In the roentgenogram, a small tumor-like mass was seen in the left hilar region; a bronchogram showing the left upper lobe bronchus entering this mass proved it to be the left upper lobe. Removal of 250 c.c. of air from the left chest failed to produce expansion of the lung; and, because of the atelectasis, bronchoscopy was performed. A small amount of mucoid secretion was aspirated from the left upper main bronchus and on the following day 400 c.c. of air were removed from the left side of the chest. Three months later complete re-expansion of the lung was demonstrable. Only one previous report of atelectasis following idiopathic spontaneous pneumothorax could be found in the literature.

The final case was that of a 28-year-old engineer who, while shoveling dirt, suddenly experienced a sharp pain in the upper anterior part of the right side of the chest, radiating to the upper abdomen. Roentgen examination demonstrated a hydropneumothorax on the right with a fluid level at the anterior end of the fourth rib. In addition, a marked collapse of the right lung with a pleural adhesion at the apex was observed. The pleural cavity was aspirated several times, hemorrhagic fluid being obtained and subsequently replaced by air. Culture of the fluid was sterile and guinea-pig inoculation was negative. The lung slowly re-expanded within a six-week interval, at the end of which time there was a recurrence. Complete re-expansion eventually occurred without further aspiration.

It is generally believed that spontaneous hemopneumothorax is due to rupture of a valve vesicle situated near the pleural surface. Treatment must be individualized. When a considerable amount of fluid is present, it is usually wise to remove it in order to relieve pressure on the mediastinum, but care must be taken not to reduce the intrapleural pressure too greatly, because of the danger of opening up an incompletely healed fistula and thus causing an increase in bleeding in the pneumothorax.

The authors believe that their case is the first to be recorded in the American literature of a large spontaneous hemopneumothorax followed by a recurrence on the same side.

STEPHEN N. TAGER, M.D.

Hydatid Cysts of the Lung. Louis R. Davidson. J. Thoracic Surg. **13**: 471–510, December 1944.

This paper is based on the author's experience with four cases of hydatid cyst of the lung and an exhaustive review of the literature. Although the disease is uncommon in the United States, it is believed that there will be more cases as service men return from countries where it is more prevalent. The incidence is greatest in sheep-raising countries, as Argentina, Uruguay, New Zealand, Australia, Italy, Syria, Greece, and Algiers.

Taenia echinococcus is found usually in the intestines of dogs which have eaten infected sheep. Innumerable ova are discharged by the dog in the feces and reach the human intestine through contaminated fruits, vegetables, and water. In man the egg migrates through the bowel wall and usually reaches the liver. From here it may get through into the lung or elsewhere in the body. The embryo then develops, forming a cyst with two layers in the wall. From the inner germinal layer, brood capsules containing scolices develop, and these if ingested by a dog develop into intestinal worms, completing the cycle.

In the lung the cyst enlarges and is surrounded by an adventitial coat from the lung, with slight atelectasis in the adjacent area. This produces a smooth, round, dense shadow on the roentgenogram. In the complicated cases air gets around the cyst between the wall of the cyst, and the adventitial coat forming the perivesicular "pneuma." The air may get inside of the cyst also, forming the double dome arch or "Cumbo's sign," and later the walls of the cyst may collapse, producing the "camalote formation." These changes are visible in roentgenograms and are supposed to be diagnostic of hydatid cyst.

Cough which later becomes productive, hemoptysis, and chest pain are inconstant complaints. Physical findings are not diagnostic. Eosinophilia is often but not always present. The complement-fixation reaction is variable. The intradermal skin test of Casoni is the best and most reliable test. Certain diagnosis is made only when hooklets, scolices, or cyst membranes are found in the sputum. The cysts occur more commonly in males and more often in the lower lobes. The treatment is surgical removal of the entire cyst.

The illustrations accompanying the article are poor.

HAROLD O. PETERSON, M.D.

Pneumomediastinum in the Newborn. Robert M. Bowman and Charles S. Culotta. Am. J. Roentgenol. 53: 7–14, January 1945.

Among the variety of conditions apparently associated with mediastinal emphysema in infants are those producing violent respiratory effects such as obstetrical labor, pertussis, and obstructive tracheobronchitis. The factor of overdistention is important. Macklin (Arch. Int. Med. 64: 913, 1939; J. Michigan M. Soc., 39: 756, 963, 1940) has shown on experimental animals that spontaneous pneumomediastinum results from pulmonary alveolar rupture. The air passes along the vascular sheaths to the mediastinum. Such factors as congenital deformities of the respiratory system, local trauma, or a pulmonary infectious process may weaken the walls of the respiratory tract so as to produce a break in their continuity and lead to the appearance of air outside of the normal pathways. From the mediastinum air may rupture into the pleural cavities and produce pneumothorax. It may pass downward into the retroperitoneal region and even along the great vessels to the groins. Sometimes it passes upward into the cervical or axillary areolar spaces.

Mediastinal emphysema occurring during the first few days of life is usually manifested by respiratory and circulatory distress. Respirations are rapid and shallow, and dyspnea and cyanosis may occur. Bulging of the precordium, distention of the neck veins, and a fall in blood pressure are due to blockage of the circulation brought about by compression of the systemic and pulmonary veins.

Though the condition may be suspected clinically, diagnosis is essentially a roentgen procedure. In the frontal view of the infant's chest, air outlining the lateral margins of the superior mediastinum may occasionally be seen. In the lateral view, marked bulging of the precordium with a large area of encapsulated air immediately posterior to the shadow of the sternum is characteristic.

The treatment of the authors' 3 cases has been conservative, oxygen and stimulants being administered as was found necessary. It is of significance that all 3 patients had received some form of artificial respiration and attempted insufflation of the lungs. It is difficult to determine whether the attempted resuscitation produced the air in the mediastinum, but it is known that such methods are hazardous and should be administered only by well trained persons.

CLARENCE E. WEAVER, M.D.

Spontaneous Mediastinal Emphysema. Henry Miller. Ann. Int. Med. *21:* 998–1010, December 1944.

The author reviews the literature on spontaneous mediastinal emphysema and adds 4 cases to those previously recorded. Macklin's theory of the genesis of the disease is that areas of atelectasis, by causing overdistention of the surrounding alveoli, may lead to escape of air into the perivascular sheaths. While no atelectatic areas could be demonstrated in the author's four cases, he describes a fifth case, following massive atelectasis, in which this mechanism was undoubtedly active.

The paths of extension of air in the mediastinum tend to follow the fascial planes, particularly the sheaths surrounding blood vessels. The air may spread upward into the root of the neck, the face, axilla, anterior chest wall and arms. It is possible for it to dissect up along the sides of the trachea to the floor of the mouth, extending under the base of the tongue, which becomes elevated. It may extend forward between the parietal pleura and pericardium to appear as blebs overlying the heart, laterally into the opposite lung, and downward into the retroperitoneal space, where it may outline the kidneys, ureters, and renal vessels.

Clinically, the spontaneous type of mediastinal emphysema is characterized by the sudden development of pain in the chest in the absence of antecedent trauma or unusual effort. The pain varies in location and severity, depending largely on the degree of distention of the mediastinal tissue. It may radiate to the upper midback, shoulders, neck, and occasionally down the left arm, as it does in angina pectoris. Its character and radiation have at times led to the erroneous diagnosis of coronary occlusion. Dyspnea, cyanosis, and orthopnea may occur but are not characteristic.

The demonstration of air in the subcutaneous tissues of the neck and anterior chest wall by palpation is diagnostic. The area of cardiac dullness is often diminished or completely obliterated, being replaced by a hyperresonant percussion note.

The pathognomonic sign of mediastinal emphysema is the peculiar sound heard over the pericardium on stethoscopy and sometimes even with the unaided ear. It has been variously described as crunching, crackling, popping, clicking, tapping, snapping, crepitant, etc., and is synchronous with the heart beat. This has been termed Hamman's sign and was attributed by him to the action of the heart on air between the anterior parietal pericardium and the chest wall.

Pneumothorax was present in some of the reported cases of mediastinal emphysema and occurred in 2 of the author's cases. It is usually small and detected only in roentgenograms, though in the author's patients it was discovered on physical examination.

For the roentgenographic demonstration of air in the mediastinium, lateral and oblique views should be taken as well as an anteroposterior view. In the anteroposterior film only the outlying pockets of air may be seen. In this projection a sharp line running parallel to the outer wall of the mediastinum may be detected in

the presence of a pneumothorax. In the lateral and oblique views, air may be visible between the heart and the anterior chest wall or in the posterior mediastinum. In rare cases when the air does not extend forward around the heart, Hamman's sign may be absent and the roentgenographic evidence of air in the mediastinum may be decisive. Air may also be detected in the subcutaneous tissues of the neck and in the retroperitoneum.

In the differential diagnosis, coronary occlusion, pericarditis, dissecting aneurysm and pulmonary embolus must be considered. These can usually be differentiated by physical examination, roentgenographic study of the chest, and electrocardiography.

Treatment is symptomatic, and the prognosis, in general, is excellent. Resorption of air from the mediastinum is rapid when the point of entry is closed.

STEPHEN N. TAGER, M.D.

Esophageal Duplications or Mediastinal Cysts of Enteric Origin. Wm. E. Ladd and H. Wm. Scott, Jr. Surgery **16:** 815–835, December 1944.

Esophageal duplications are cystic structures of variable size with thick walls, lined with mucous membrane. They arise in the posterior mediastinum and usually expand into the right or left hemithorax, remaining retropleural in location. The cysts have been encountered along the entire length of the mediastinum but are most common in the middle third.

The duplications usually have a two-layered muscular wall resembling esophagus. The mucosa, however, does not necessarily correspond to that of the eosphagus; it may closely simulate that of the stomach, and some of the cysts show elements of both esophageal and gastric mucosa. A true serosa is absent, although the pleura is occasionally reflected over the larger cysts so as to resemble grossly a serosal coat.

A significant feature from the surgical point of view is the frequency of an intimate attachment to the esophagus, though an occasional case shows no such attachment.

The contents of the cysts usually resemble gastric juice. The size varies; the largest in the authors' series of 5 cases filled two-thirds of the right thoracic cavity in a 22-month-old boy, while the others averaged about 5 cm. in diameter.

Numerous theories have been proposed to explain the occurrence of alimentary duplications in general. Keith attributes duplication to failure of coalescence of embryological vacuoles in the solid stage of the alimentary tube, so that a continuity of lumen is not established, thus leaving a cystic structure contiguous to some portion of the alimentary tract. This explanation the authors believe to be the most rational one.

Like other forms of alimentary duplication, duplications of the esophagus are usually encountered in infancy and early childhood. The youngest of the authors' patients was three weeks of age, while the oldest was twenty-two months. The oldest patient reported in the literature was three and one-half years of age. The sex incidence is equal.

The symptoms are not only those of an expanding mediastinal mass, but in addition there may be the complicating features of peptic ulceration of the cyst wall. Cough, dyspnea, cyanosis, and recurrent or chronic pneumonias are common presenting complaints. Dysphagia and regurgitation of feedings occur with impingement upon the esophageal lumen. Pain may be caused by distention of the walls of the cyst. Hematemesis and hemoptysis may occur separately or even in the same patient.

Physical examination usually discloses definite indications of thoracic disease, with obvious respiratory difficulty and occasionally cyanosis. There may be massive pleural effusion with signs of chronic pneumonitis and pulmonary compression.

Esophageal duplications present roentgen changes characteristic of posterior mediastinal tumors or cysts. Details of the outline may be obscured by secondary changes in the lung and particularly by pleural fluid. Most duplications are roughly spherical in contour and have a uniform homogeneous density due to their fluid content. The heart and mediastinal structures may be displaced.

Lipiodol bronchograms usually show pulmonary compression by the retropleural duplication and aid in differentiating the latter from bronchiogenic cysts and anomalies. Fluoroscopy of the esophagus with a contrast medium showed no fistulous connection between duplication and esophagus in any of the authors' patients. However, the esophagus was frequently displaced or angulated by the adjacent mass. Esophageal duplications occasionally erode the bodies of the thoracic vertebrae or the overlying ribs.

Surgical extirpation of a duplication of the esophagus is best accomplished by marsupialization of the cyst and subsequent destruction of its mucosal lining.

Reports of the authors' five cases are included. Two of the patients died. J. E. WHITELEATHER, M.D.

Chronic Constrictive Pericarditis Due to a Foreign Body (Needle) in the Pericardium. Bernard Straus. Am. Heart J. 28: 805–809, December 1944.

A 46-year-old man was admitted to the hospital with a diagnosis of "cirrhosis of the liver with possible obstruction." His chief complaints were loss of weight and abdominal enlargement. According to the history, seven years previously, while he was under an anesthetic for the correction of multiple fractures sustained in a fall, his heart had stopped and he had been given an injection in the third right intercostal space. In the course of this procedure the needle had broken off and was not recovered. About two weeks later a pericardial effusion had developed.

On admission the patient did not complain of pain or shortness of breath. There was no cyanosis in the erect or sitting position, but with the patient supine the face and neck assumed a dusky cyanotic hue. The liver was enlarged and ascites was present.

A roentgenogram of the chest showed fragments of the broken needle in the right border of the pericardium. The heart was not enlarged. Fluoroscopic examination revealed feeble cardiac pulsations, with no change in the shape or size of the heart during forced inspiration and expiration.

The history, roentgen findings, electrocardiographic and other laboratory data led to a diagnosis of chronic constrictive pericarditis of traumatic origin, enlargement of the liver and ascites, and a metallic foreign body in the right side of the chest. The operative findings were: evidences of an old inflammatory process in the intercostal muscles; diminished cardiac excursions; a large pericardio-diaphragmatic adhesion which was severed; thick, indurated and densely adherent pericardium and fused epicardium. The pericardium over the right side of the heart was removed

In the region of the inferior cava, the two fragments of the needle were found embedded in a dense fibrous sheath and were removed. A suppurative pneumonia developed and death ensued.

The author believes the pathogenesis in this case is related to two factors: (1) the development of an acute inflammatory process beginning at the site of the needle and (2) fibrosis due to chronic irritation of the pericardium because of the needle itself. The first is substantiated by evidence of an old infection of the intercostal muscles along the course of the needle and by the development of a pericardial effusion shortly after the injury. The latter idea is supported by the fact that the thickening, fibrosis, and induration of the pericardium were maximal at the site of the needle.

HENRY K. TAYLOR, M.D.

Echinococcus Cyst of the Heart: Report of a Case. Zizmor and M. M. Szucs. Am. J. Roentgenol. 53: 15-19, January 1945.

Echinococcus cyst of the heart is rare, only 4 cases having been reported previously in the American medical literature, 3 at autopsy and 1 in a living patient; 59 cases were found in the foreign literature. Left-sided cysts appear to be more common than right.

Echinococcus infestation usually occurs in childhood, but the cyst may remain latent for many years. The roentgenologic observation of a rounded mass surrounded by a ring of calcification is of the greatest diagnostic importance. The electrocardiographic findings are non-specific. Eosinophilia is present in 50 per cent of cases with active hydatid disease, while immunologic tests with echinococcus antigen are positive in 87 per cent of active cases. These tests, however, are group specific rather than species specific, and other types of cestode infestation must be ruled out by stool examinations. Immunologic tests may be negative if the echinococcus cyst has been cured or if its contents have become caseous and inert.

This lesion must be differentiated from such cardiac and pulmonary conditions as gumma, aneurysm of the heart, rhabdomyoma, dermoid cyst, simple pericardial cyst, congenital lung cyst, and tuberculous abscess of the lungs or heart with calcification. In all these conditions the echinococcus serologic tests are negative and the characteristic ring-like calcification is not demonstrable roentgenographically

A case is presented of echinococcus cyst of the wall of the left ventricle of the heart in a man of twenty-eight, always resident in the United States. It was symptomless and was discovered on routine chest examination at a maritime training station. There was electrocardiographic evidence of myocardial involvement; the intradermal test with echinococcus antigen was positive, and other types of cestode infestation were excluded.

CLARENCE E. WEAVER, M.D.

THE DIGESTIVE SYSTEM

Diagnosis of Disorders of the Small and Large Intestine. Everett D. Kiefer. New York State J. Med. 44: 2342-2349, Nov. 1, 1944.

This paper was delivered before a general medical meeting and presents for the general practitioner the symptoms and roentgen signs of disorders of the small and large intestine. Thirteen cases are reported to illustrate the important points in the roentgenologic diagnosis of a few of the more common disorders of the intestine. Roentgenograms are reproduced in 9 cases.

Deficiency Bowel Pattern in Polish Refugees, African and Indian Adults and Children (Kwashiorkor). J. Scott Brown and H. C. Trowell. Lancet 2: 812-816, Dec. 23, 1944.

Working in Uganda (Central Africa), the authors have found numerous cases of malnutrition exhibiting a characteristic clinical picture—a dermatosis consisting of scaly, shiny, dark brown areas; mental depression and sluggishness, and a variety of gastro-intestinal symptoms. The present report is based on a series of 16 such patients examined radiologically and found to show the "deficiency pattern" described by Golden (Radiology 36: 262, 1941). This group included 2 Polish refugees, 1 Englishwoman, 1 Indian, 10 immigrant African laborers, and 2 African children suffering from the nutritional disorder known locally as kwashiorkor. In all these cases there was a history of inadequate diet over a long period, deficient in total calories, animal protein, fat, green vegetables, and many vitamins.

Roentgen examination in these cases was handicapped by lack of films, and reliance was placed chiefly on fluoroscopy, which usually limited the diagnostic criteria to evidence of gross segmentation. Films were taken only for illustrative purposes, in a selected series, to observe the effect of treatment. In addition to segmentation, examinations often showed, in the small intestine, smoothing of the plicae in the jejunum and coarse flecking, but these features could be distinguished with certainty only on films. In the preliminary fluoroscopy, great gas-distention of the colon was common. Some large atonic stomachs were seen, and in general these "became brisker in their movements after treatment." The appearance of the small intestine conformed to Golden's description; segmentation was usually seen in the middle part. In 2 cases there was great distention of the duodenum with no demonstrable obstruction. As a rule, the colon was wide and poorly haustrated and tended to show segmentation also. Nevertheless, in such cases the colon emptied well. It seemed as if the normal colonic mechanisms were functioning badly and were being assisted or replaced by an alternative mechanism. Outlining of the gas-distended colon by an even layer of barium, 0.5 cm. thick, was often seen. In no case was there any enlargement of the heart as in beriberi. The soft tissues in many cases were remarkably radiolucent, even where no gas-distended intestine intervened. The authors believe this probably indicates a deficiency of minerals in these tissues. Roentgenograms for 3 cases are reproduced.

The patients did not improve on an adequate diet, and the addition of vitamin concentrates was necessary. Early cases responded well to supplementary cooked liver or brewers' yeast, given daily. In more advanced cases very large doses of crude liver extracts, given parenterally, were required. Most of the cases thus treated eventually showed clinical and roentgen evidences of cure. Patients with very advanced deficiency states, especially with infections, did not respond to any form of treatment and soon died. The condition of a few patients improved up to a certain point and then remained stationary.

The relationship of this deficiency syndrome to pellagra or beriberi is uncertain.

Simulation of Chronic Bacterial Dysentery by Paratyphoid B Infection. Daniel N. Silverman and Alan Leslie. Gastroenterology 4: 53–59, January 1945.

Four cases with generally similar features, all suspected of being chronic bacillary dysentery, are presented. Only one of these, however, actually was chronic bacillary dysentery (Shiga). The other three were found to be due to *B. paratyphosus B* of identical strain as shown culturally and by cross-agglutination. Though this is presumably the first report of chronic intestinal infection simulating chronic dysentery, caused by *B. paratyphosus B*, the authors have made this observation in 10 cases in a period of as many months. The principal features of both infections are a more or less protracted history of abdominal pain, intermittent diarrhea with or without blood or mucus, malnutrition, which may be severe enough to produce the syndrome of avitaminosis, and hypochromic anemia. The resemblance of these cases has been roentgenographic as well as clinical. The more or less constant finding in cases of chronic bacillary dysentery has been the so-called deficiency pattern in the small intestine, *i.e.*, flocculation of the contrast medium and abnormal segmentation of the bowel. This expression of deficiency has been shown to occur to a high degree in the chronic cases of paratyphoid B infection.

In the cases of dysentery, there is generally skin sensitivity to several strains of the dysentery bacillus, but none to organisms of the *Salmonella* group, whereas in patients with chronic paratyphoid B infection, the converse is true: there is skin sensitivity to several *Salmonella* bacilli, but none to members of the dysentery group. In the syndrome of *B. paratyphosus B*, there is heterologous cross-agglutination, as well as homologous agglutination of the organisms by sera of various patients in the group.

Isolated Sarcoidosis of the Small Intestine Simulating Non-Specific Ileo-Jejunitis. C. J. Watson, L. G. Rigler, O. H. Wangensteen, and J. S. McCartney. Gastroenterology 4: 30–50, January 1945.

Two cases of sarcoidosis involving the small intestine and mesenteric lymph nodes are presented.

Case I. An unmarried female, 21 years of age, was admitted to the hospital because of lassitude, weakness, and anorexia of approximately one year's duration, with diarrhea and irregular fever for eight months. The examination was negative except for a rather extensive involvement of the small intestine as shown on the x-ray film. This differed from the usual regional ileitis or ileojejunitis in being more diffuse and in exhibiting an appearance suggestive of an extensive polyposis. Roentgen examination of the chest and of the bones of the hands was negative. The Mantoux test was negative at a dilution of 1:100 (1 mg.). Resection of much of the involved bowel resulted in a remission of five months' duration, after which there was recurrence of mild fever and diarrhea as well as some of the roentgen findings. Following a second operation, at which more of the small bowel was resected, including the entire ileum, the patient had remained in excellent health up to the time of the report, although the presence of slight temperature elevation, a low-grade anemia, and increased sedimentation rate were suggestive of mild activity either in the remaining bowel or in other viscera. The pathological study revealed extensive nodular involvement of the resected loops of small intestine with production of a "cobblestone" or hobnail appearance of the mucosa. This change is demonstrated in the roentgenograms. The mesenteric lymph nodes were enlarged and showed diffuse involvement. Histologically, the lesions were typical of sarcoidosis, *i.e.*, epithelioid-cell tubercles with and without giant cells. Caseation was entirely absent, as shown by silver impregnation of the reticulum in the centers of the tubercles.

Case II. A married woman, 25 years of age, was admitted to the hospital because of diarrhea, "gas" and distention, weakness, nausea and vomiting, and progressive weight loss over a period of two years. Except for distinct clubbing of the fingers and temperature ranging between 99 and 101° F., physical examination showed nothing of significance. The Mantoux test was negative at 1:100 (1 mg.). X-ray examination of the chest and bones, including the hands, was negative. Films of the small bowel revealed findings indicating a regional ileitis with some changes in the jejunum of undetermined type. A few areas suggestive of the polyposis-like picture seen in the first case were also observed here. Resection of the involved ileum and some of the cecum resulted in prompt improvement, which had been maintained up to the time of the report. No evidence of jejunal involvement was found at operation. There was no further fever, and the patient gained twenty-five pounds in weight, but a mild diarrhea persisted. A recent x-ray examination revealed evidences which might explain the residual symptoms. There were both marked hypermotility and stasis in several adherent localized bowel segments.

In each of these cases the clinical picture simulated in many respects that of regional ileitis or Crohn's disease. Certain characteristics, however, often present in the latter condition were lacking, as a mass in the right lower quadrant, signs of local peritonitis or fistula development, and the x-ray manifestation known as Kantor's "string" sign. The roentgen findings show other distinct differences from the ordinary picture of ileojejunitis. The abnormal changes were generalized rather than segmental. The mucous membrane pattern suggested swelling and hypertrophy of the folds rather than denudation. Furthermore, the polyposis-like picture in the small intestine is a most unusual finding and is not seen in regional enteritis. Attention to this group of findings may suggest a diagnosis of sarcoidosis in future cases.

Roentgenograms and photomicrographs are reproduced.

Primary Carcinoma of the Third Portion of the Duodenum. Thomas A. Shallow, Sherman A. Eger, and James B. Carty. Surgery 16: 939–946, December 1944.

Primary carcinoma of the small intestine is of comparatively unusual occurrence; in the third portion of the duodenum it is extremely rare, only 12 authentic cases having been previously reported.

The authors' patient was a 63-year-old white man complaining of intermittent attacks of epigastric fulness one-half to one hour after meals, relieved by belching. At the onset, a year before admission, these attacks occurred at intervals of four to six weeks. They increased in frequency and severity, and for the two weeks prior to admission, symptoms had been constant, with vomiting of bile-stained material. The vomitus contained particles of food ingested several meals earlier but no blood. The patient had lost [illegible] pounds in the last six months.

A deep, thick, firm, non-tender mass, 2 inches in diameter, was palpable just above the umbilicus. The blood picture showed a slight anemia with a normal white cell count. Gastric acidity was slightly decreased, with bile present in all specimens. Urinalysis and blood tests were negative. Repeated roentgen studies showed almost complete obstruction at the beginning of the ascending loop of the duodenum.

At operation a tumor was found involving the posterosuperior wall of the third portion of the duodenum beneath the superior mesenteric vessels. The adjacent retroperitoneal tissue was indurated, but there was no evidence of extension of the growth or of metastasis. The entire third portion of the duodenum was mobilized and resected and the free ends of the bowel were closed. An antecolic duodenojejunostomy was performed in a side-to-side manner anastomosing the jejunum, about 10 inches from the ligament of Treitz, to the second portion of the duodenum, just distal to the the ampulla of Vater. The jejunal stump was attached to the ligament of Treitz leaving the proximal jejunum available for a gastro-enterostomy should the duodenojejunostomy stoma prove inadequate. Nine months after operation the patient was symptom-free; he had gained weight, and an x-ray examination showed no abnormality.

The removed segment of duodenum contained a central penetrating ulcer 2 cm. in diameter. The cells showed marked hyperchromatism and a few mitotic figures. They infiltrated the entire submuscularis mucosa, submucosa, and a portion of the muscle layers. The diagnosis was primary ulcerative adenocarcinoma of the duodenum. J. E. WHITELEATHER, M.D.

Carcinoma and Lymphosarcoma of the Colon. A Case of Lymphosarcoma of the Descending Colon. Benjamin T. Tilton. Am. J. Surg. *66*: 300–308, December 1944.

Having encountered a lymphosarcoma arising in the descending colon, the author calls attention to the possibility of this type of new growth and the importance of bearing it in mind, "particularly in suspected carcinoma with atypical manifestations."

Carcinoma of the colon is a disease of later life. In its early development it does not give rise to a definite clinical picture, but any abdominal symptoms, however vague and slight, if they persist in spite of the usual dietetic and medicinal measures, call for a thorough examination. The patient may complain of a feeling of abdominal pressure, especially on the right side, colicky pains, gaseous distention, and loss of appetite. Painful distention on the right side is a particularly important sign, especially in elderly persons, when it cannot be attributed to appendicitis. Anemia in an elderly patient is also significant. Persistent abdominal pain, visible blood in the stools, or changes in the bowel habit, particularly increasing constipation, usually lead the patient to consult a physician. A palpable tumor is likely to be a late symptom and is found more often in carcinoma of the cecum and ascending colon. Dyspeptic symptoms are more characteristic of right-sided carcinoma and are frequently associated with pain or discomfort on the right side suggesting appendicitis or cholecystitis. Anemia, which is of toxic origin and not due to loss of blood, is also suggestive of a right-sided growth, since the right side of the colon has a function chiefly of absorption. Obstruction is the outstanding sign of carcinoma of the left colon and has been estimated to occur six times more frequently than when the lesion is on the right side.

An important roentgen sign of carcinoma is a narrowing of the colon which remains constant at a definite point; this remains visible in spite of manipulation or insufflation with air after the expulsion of the barium enema. A second sign is a persistent irregularity in outline of the colon, especially when accompanied by spasm. Not infrequently an exploratory operation has revealed a carcinoma after negative x-ray studies, and a diagnosis of simple spasm of the colon should not be made on the basis of a single examination. Atropine should be given before the second examination. If the narrowing of the lumen is still present, the stricture is probably organic in nature. Lesions of the rectosigmoid junction are frequently not revealed roentgenologically. For this reason, sigmoidoscopy should also be employed when a growth is suspected in this area.

In contrast to carcinoma, lymphosarcoma of the intestine is found most commonly in patients under forty; it is especially common in childhood, when it has a rapid course. The neoplasm originates in the lymphoid tissue of the intestinal wall. Perforation of the mucosa and serosa is unusual, but there may be adhesions with adjacent structures. Cicatricial narrowing of the intestines does not occur as in carcinoma, but rather a dilatation of the wall, as in aneurysm, due to a loss of function of the muscular layer. Metastasis takes place early, to the mesenteric lymph nodes and omentum. These secondary tumors may reach a large size and overshadow the original growth in the intestinal wall. A chronic peritonitis with fluid is not infrequent.

A diagnosis of lymphosarcoma of the intestine is rarely made before operation or autopsy. General symptoms, such as anemia and loss of strength and weight, may be the first evidences of the condition. In some cases local symptoms, such as abdominal pain, sometimes of a colicky nature, may be the first to appear. Acute obstruction of the intestine is rare and is due to intussusception, adhesions, or plugging of the lumen. A mass is a common finding. Roentgenography is not very helpful in the diagnosis of lymphosarcoma. When the small intestine is involved, there may be some dilatation of the intestinal loops with a tendency to local stasis. In the colon, a barium enema may show a deformity or filling defect.

The treatment of both carcinoma and lymphosarcoma of the colon is discussed. The improved prognosis in carcinoma is stressed, with still greater improvement to be hoped for from earlier diagnosis, more thorough preoperative preparation, improved operative technic, and chemotherapy. The results with irradiation in lymphosarcoma of the colon are not encouraging.

The author's case of lymphosarcoma, in a 73-year-old woman, is reported.

Radiologic Aspect of Gall-Bladder Disease. M. C. Sosman. New England J. Med. 231: 786–794, Dec. 14, 1944.

This is a lengthy and detailed review of the history, chemistry, technical, and diagnostic features of x-ray examination of the gallbladder.

The proper preparation of the patient for the examination is discussed in great detail, and the possibilities of error are pointed out. Radiography should

be of the best to capture the finest details. Errors in interpretation are considered at length. Newer methods and procedures are discussed.

JOHN B. MCANENY, M.D.

Multiple Diffuse Pancreatic Lithiasis. Roentgen Anatomy of the Pancreas: Case Report. Harold H. Sage. Am. J. Roentgenol. 53: 28–32, January 1945.

Published cases of pancreatic lithiasis are rather rare. The author's case showed sufficient pancreatic calcification to demonstrate the position and relationships of the pancreas. From the head, which overlies the first and second lumbar vertebrae, the organ extends diagonally upward into the left upper quadrant. The body reaches above the lesser curvature of the stomach; the tail crosses the upper part of the left kidney and extends to the hilus of the spleen. It is also in direct relation with the splenic flexure of the colon.

The case reported was of interest, also, for the demonstration of abnormalities in the small intestinal pattern, namely, segmentation, obliteration of mucosal pattern, exaggeration, irregularity and coarsening of the mucosal folds, and hypertonicity. There were also variations in motility of the small bowel. The patient did not manifest any gross clinical evidence of pancreatic insufficiency, but early insufficiency was indicated by a markedly increased excretion of fat and protein in the stools, with characteristic color and bulk.

The case is reported in detail and reproductions of roentgenograms are furnished showing the relationships of the pancreas and the small bowel pattern changes.

CLARENCE E. WEAVER, M.D.

THE SKELETAL SYSTEM

Study of the Relative Importance of the Cortex and Spongiosa in the Production of the Roentgenogram of the Normal Vertebral Body. George W. Wagoner, Andrew D. Hunt, Jr., and Eugene P. Pendergrass. Am. J. Roentgenol. 53: 40–48, January 1945.

Three adult human lumbar vertebrae were obtained at necropsy and prepared as follows: From one the cortex was removed, from another the soft tissues alone were stripped, and in the third the soft tissues and the spongiosa were removed, leaving only a cortical shell. The vertebrae were then immersed in a water phantom and were examined roentgenographically under conditions designed to duplicate those obtaining in the human subject. From this experiment the conclusion was drawn that the "shadow value" of the spongiosa is greater than that of the cortex in producing the characteristic roentgenogram of the vertebral body.

In order to determine the cause of the transverse horizontal shadow seen in 20 per cent of adult vertebrae in lateral films, some further experiments were conducted. An artificial defect made in the cortex along one lateral wall failed to show any shadow of lessened density in lateral roentgenograms. A defect, 3 mm. in diameter, cut through the center of the spongiosa by a small curette introduced through the posterior foramina in an anteroposterior direction, showed a shadow of lessened density in the lateral roentgenogram. In a further study of the "transverse markings," a normal adult vertebra was cut in seven parallel sections in its sagittal plane. These sections were roentgenographed *in toto* and in various combinations. The central sections alone showed the "transverse marking." It is concluded from this experiment that the "transverse marking" is produced by the peculiar structure of the central area of the body. This corresponds in location and size to the central reservoir of the sinusoidal system shown previously to exist within the central structure of the vertebral body.

A study was also made to determine the minimum size of lesions demonstrable roentgenographically. It was found that very small defects in the spongiosa could be demonstrated, but a cortical defect 10 by 10 mm. failed to show in the roentgenogram.

CLARENCE E. WEAVER, M.D.

A Method for Studying Healing of Bone. Alfred Marshak and R. L. Byron, Jr. J. Bone & Joint Surg. 27: 95–104, January 1945.

The authors have used radioactive elements as tracer substances to investigate the healing of bone. Radiostrontium is closely related to calcium and was used instead of radiocalcium because of technical reasons. Both radiostrontium and radiophosphorus behave as the non-radioactive strontium and phosphorus. Strontium has been found to be retained where new tissue is being formed and, like calcium, is concentrated in bone.

The radioactive elements were injected intraperitoneally into rats with freshly fractured tibias, and the concentration of radioactivity was determined by a Geiger-Müller counter.

Complete data on counts are presented in table form and the concentration of radioactive elements is accurately followed.

JOHN B. MCANENY, M.D.

Early Recognition of Endocrine Disorders in Childhood by Roentgenograms of the Wrist to Determine the "Ossification Index." Donald W. Leonard. Am. J. Roentgenol. 53: 55–61, January 1945.

Several authors have emphasized the relation between endocrine disturbances and the easily obtainable facts about ossification. It has been demonstrated that subsequent roentgenograms may be relied upon to show the effectiveness of endocrine therapy. As pointed out by Clark (Am. J. Roentgenol. 35: 752, 1936), it is reasonable to accept roentgenographic changes in the wrist as a good index of the extent of departure from the usual rate of ossification throughout the entire body. One reason for this is that this area contains so many primary centers of ossification.

From a summary of the studies of ossification centers in the wrist by various observers, the author has made a diagram of the wrist showing the latest appearance of ossification in each of these centers in the normal child. The capitate and hamate are numbered 6 and 7, respectively, representing the latest appearance in *months* for these centers. The other centers are given numbers representing their latest normal appearance in *years*. The distal epiphyses of the radius and ulna are included. This gives a total of nine centers (the pisiform is not included). The index for the detection of delayed ossification is constructed by setting down the actual age of the patient followed by the figures for the centers actually present. These are placed in their chronological order and zero is substituted if any center has not yet appeared. A separation is made with hyphens between the figures representing months and those representing years. Thus the normal index for the full complement of centers at the age of

seven years becomes 7-67-2456777. At the age of three the normal would be 3-67-2000000. With figures like these on the patient's record, any deviation from the normal becomes immediately obvious. Since the index figures represent the *latest* normal appearance of the centers, some cases which are normal will be found to have centers whose assigned figures are greater than the actual age. CLARENCE E. WEAVER, M.D.

Fracture Dislocation of the Ankle Occurring in Flying Accidents. Theodore James. Brit. M. J. **2**: 372–373, Sept. 16, 1944.

Fracture dislocations of the ankle in fliers occur most often as a result of a crash landing, where the motor is normally in front of the pilot. Sudden displacement of the rudder bar causes extreme dorsiflexion of the foot. The talus is separated at its mid point, and the posterior half, with the fibula and tibia, is displaced posteriorly.

Treatment is urgent, as there is serious interference with the blood supply to the talus. Either open reduction or partial talectomy is advised. In extreme cases total talectomy and arthrodesis may be required.

Q. B. CORAY, M.D.

Sacral Fractures and Injuries to the Cauda Equina. J. Grant Bonnin. J. Bone & Joint Surg. **27**: 113–127, January 1945.

This is an interesting and stimulating article on fracture of the sacrum. The incidence of sacral fracture in association with fractures of the pelvis varies widely according to different authorities. In the author's series of 44 pelvic fractures, there was roentgen evidence of involvement of the sacrum in 20 or 45 per cent.

The weakest portion of the sacrum is through the first and second foramina, and this is usually where the fracture line is to be found. The fracture may occur from rotation where the lower extremity is hyperextended; from leverage where the pelvis is "run over" and its two halves separated; and from shear, where one-half of the pelvis is driven backwards by impact against the knee.

The anatomy of the pelvic bones must be well understood and a good view of the sacrum should be obtained for diagnosis. The obstetric view of the inlet is often of great advantage. Inequalities of the two sides of the sacrum must be considered. At times the fracture is not evident until several weeks have elapsed.

Neurologically, the first and second sacral nerves are affected, producing a combination of motor changes which is readily recognizable. There are weakness of plantar flexion at the ankle, loss of ankle jerk, and loss of power of the hamstrings and glutei. Marked paralysis of the biceps femori was observed in all the author's cases. The calf muscles and hamstrings are tender to the touch. There may be alteration in sensation, paresthesia and referred pain on the outer side of the calf and foot. Bladder and bowel changes are due not to nerve injury but to trauma. Vasomotor and trophic changes are not found.

Treatment of sacral fracture is that of the rest of the pelvis. The pelvis is usually consolidated in about eight weeks and walking is then encouraged. In lesser injuries complete recovery should be attained in a year, but with severe injuries there may be permanent impairment of gait and limitation of activity.

Case reports are presented and drawings and roentgenograms of various types of fracture are reproduced.

JOHN B. MCANENY, M.D.

Congenital Stricture of the Spinal Canal. Münir Ahmed Sarpyener. J. Bone & Joint Surg. **27**: 70–79, January 1945.

The author has made extensive studies of patients with uncontrolled enuresis, spastic deformities of the lower extremities, and clubfoot. In many of these a stricture of the lumbar spinal canal can be demonstrated by suboccipital injection of lipiodol. Release of the constricting bone and soft tissue produces striking results, with almost immediate postoperative relief of enuresis and definite improvement in the spastic states of the lower extremities.

Many good reproductions accompany the article. It comes from Istanbul, Turkey.

JOHN B. MCANENY, M.D.

Osteochondritis Dissecans of the Supratrochlear Septum. H. S. Morton and W. E. Crysler. J. Bone & Joint Surg. **27**: 12–24, January 1945.

The supratrochlear septum is a thin lamina of bone separating the olecranon fossa from the coronoid fossa at the distal end of the humerus. The anterior surface of the septum is entirely within the elbow joint space and covered with synovial membrane. The posterior surface is only partially covered with synovial membrane. As a result of repeated trauma, the anterior surface is at times the site of an osteochondritic process, just as in other joints, and an aseptic sequestrum forms.

The authors describe 6 cases of osteochondritis dissecans of the supratrochlear septum and reproduce roentgenograms of the condition. They believe that these are the first cases to be recorded.

JOHN B. MCANENY, M.D.

Multiple Myeloma in a Fifteen-Year-Old Boy. Michael A. Rubinstein. New York State J. Med. **44**: 2491–2494, Nov. 15, 1944.

A case of plasma-cell multiple myeloma in a boy of fifteen is reported. The patient gave a history of bone pains for three years and of pathologic fracture of the femur. The original diagnosis, on the basis of clinical x-ray studies, was osteosarcoma. Hand-Schüller-Christian disease was also considered. Examination of aspirated sternal marrow, however, showed plasma myeloma cells, and the diagnosis of myeloma was advanced, though at that time no substantiating evidence was found in either the blood or urine. Subsequently, Bence-Jones protein appeared in the urine, at first intermittently and in small amounts, later more often and in increasing quantity. Biopsy of a skull lesion, localized roentgenographically, confirmed the diagnosis. Finally, the blood proteins, at first showing a low normal level with an especially low globulin content, started to rise, attaining 9.1 per cent as compared to 5.2 per cent at the time of the first bone marrow aspiration, about a year previously.

This case emphasizes the importance of bone-marrow aspiration in the diagnosis of myeloma.

GYNECOLOGY AND OBSTETRICS

Role of Roentgen Pelvimetry in the Management of Pelvic Contraction. E. L. King. New Orleans M. & S. J. **97**: 302–306, January 1945.

The author takes a "middle of the road" attitude, believing that roentgen pelvimetry is unnecessary in certain cases and of definite aid in others. It is not es-

sential in the multipara with a history of normal delivery of normal-sized children or in the primipara with a clinically adequate pelvis having ischial spines that are not prominent and are well spaced and with the head engaged before labor starts.

Roentgen information, on the other hand, is desirable in (*a*) the multipara with a history of previous dystocia; (*b*) the multipara who has previously delivered a small child and now presents herself with a much larger child; (*c*) the primipara with an abnormal pelvis or with an oversized child; and (*d*) in breech presentations.

The Ball technic, which gives the volume capacity of the pelvis at various planes and the volume of the fetal head, and the Johnson method of calculating the various diameters are employed. Although it is generally agreed that molding of the fetal head will compensate for a discrepancy of 200 c.c. between the volume of the head and that of the pelvis at any level, the author prefers cesarean section if the pelvic volume is exceeded by 180 or 190 c.c.

The greatest assistance from the roentgenogram is obtained in the study of the plane of least pelvic dimensions. This is demonstrated by a listing of the measurements in 7 cases in which the mid-plane (interspinous or bi-ischial) transverse diameter was less than that of the outlet.

LESTER M. J. FREEDMAN, M.D.

The Outlet Contraction with Especial Emphasis on the Typical Funnel Pelvis. Ralph E. Campbell. Illinois M. J. 86: 302–310, December 1944.

Funnel pelvis is generally recognized as a contraction in which the transverse diameter of the outlet measures 8 cm. or less, or in which the distance between the lower margin of the symphysis and the tip of the sacrum falls below 9 cm. Three groups are distinguished: (1) typical, in which the superior strait is normal while the inferior strait is contracted; (2) generally contracted, in which the entire pelvis is smaller than normal, while the inferior strait is narrowed to a greater extent than is usual in typical justo-minor pelves; (3) complicated, including a small number of flat or rachitic pelves and cases of osteomalacia, spondylolisthesis, and lumbosacral kyphosis, in which the outlet contraction is superadded to the typical deformity. The commonest etiologic factor in the typical funnel pelvis is lumbosacral assimilation.

Two cases in which x-ray pelvimetry was a valuable adjunct to ordinary pelvimetry are presented. The first patient had a typical funnel pelvis with a narrow intertuberous diameter. The posterior plane of the pelvic outlet was sufficiently compensated, however, by a long posterior sagittal diameter to permit successful spontaneous delivery. In the second case there was an outlet contraction uncompensated in the posterior sagittal diameter. Cesarean section was elected.

ELLWOOD W. GODFREY, M.D.

THE GENITO-URINARY TRACT

Diagnosis of Hydronephrosis Caused by Accessory Renal Vessels. Earl C. Lowry, Joseph C. Hayward, and Donald E. Beard. J. Urol. 52: 492–496, December 1944.

The authors discuss the symptomatology and diagnosis of hydronephrosis caused by lower pole accessory renal vessels and report a case of hydronephrosis of 5,000 c.c. capacity.

Three separate and distinct types of pyelograms are obtained, depending upon whether the obstructing vessel crosses the renal pelvis, the uretero-pelvic junction, or the ureter. When the obstruction is at the uretero-pelvic junction and the ureteral catheter has passed the obstructing vessel, the pyelogram shows a symmetrically enlarged renal pelvis with a smooth, even contour along its inferior border; the opaque medium is absent at the junction and the ureter is not seen to enter the pelvis.

When the accessory vessel crosses the renal pelvis, it leaves a portion of the pelvis distal to the obstruction which, on the pyelogram, appears crescent-shaped, and the hydronephrotic sac is less distinctly filled. In this type of obstruction, the ureter is well filled and is seen to connect with the renal pelvis.

In obstructions below the uretero-pelvic junction, the ureter and pelvis are dilated above the obstruction and the ureter distal to this point is poorly filled with dye, if at all.

A case is reported of a 31-year-old enlisted man who had a left hydronephrosis due to obstructing aberrant vessels which crossed the renal pelvis proximal to the uretero-pelvic junction. After nephrectomy, the patient returned to full military duty.

N. P. SALNER, M.D.

The Renal and Ureteral Changes Induced by Dilating the Ureter. An Experimental Study. Laurence F. Greene. J. Urol. 52: 505–521, December 1944.

An experimental study on dogs was undertaken to determine the effects of ureteral dilatation on the ureter and kidney. This is of interest because ureteral dilatation is practised clinically and because adynamic hydronephrosis—*i.e.*, hydronephrosis without mechanical obstruction to the outflow of urine—has recently received much attention.

In the normal dog excretory urograms are unsatisfactory since insufficient medium rests in the tract. Moderate dilatation of the dog ureter (9 to 11 F) results in a decrease in the rate and amplitude of ureteral contraction, a decrease in the rate of transmission of urine down the ureter, and improved unilateral visualization of the urinary tract by excretory urography. Wide dilatation (14 to 16 F) results in ureteral hypertonicity, which acts as a functional obstruction and produces acute pyelectasis and ureterectasis. Repeated wide dilatation of the ureter produces permanent hydronephrosis and hydroureter.

The histologic changes in the ureter resulting from dilatation are loss of mucosa, edema of the submucosa, stretching and rupture of the smooth muscle, and widespread hemorrhage.

The author draws some conclusions of clinical interest.

EDWIN L. LAME, M.D.

Diverticulum of the Female Urethra. Leon Herman and Lloyd B. Greene. J. Urol. 52: 599–610, December 1944.

The authors define urethral diverticulum as a sac communicating with the urethra and lined by a continuation of the urethral mucosa. Other cavities similarly disposed but lacking a mucosal lining are designated pseudodiverticula. Most authors believe that both diverticula and pseudodiverticula of the urethra

are acquired and usually occur in the absence of urethral obstruction. Trauma incident to childbirth is a frequently ascribed cause. The condition is relatively more common among Negresses, probably owing to the greater frequency and neglect of urethral infections and poor obstetrical care. Calculi occur in 17 per cent of the cases, the majority developing *in situ* from urinary crystals.

There may be no symptoms. In most cases there is mild vesical irritation; rarely obstructive symptoms occur. The inflamed sac is painful, and spontaneous urethral hemorrhages may originate from ulceration or a complicating neoplasm.

The majority of diverticula are about the size of an English walnut and attached to the floor of the middle third of the urethra, so that the patient may observe a painless lump in the vagina. Acute inflammation may lead to closure of the orifice and preclude instrumental studies. Roentgenography, urethroscopy, and urethrography are employed diagnostically and to determine the size and location of the orifice or orifices, the size, location, and form of the sac, whether unilocular or multilocular, and whether smooth-walled or with filling defects suggestive of neoplasm. X-ray visualization of a soft shadowgraph catheter or opaque medium introduced into the cavity is a useful diagnostic measure, but less valuable than cysto-urethrography. In performing the latter the bladder is filled with 10 per cent skiodan and a 20 per cent solution is then injected into the urethral meatus. Urethrograms made after filling the bladder and during voiding have not proved satisfactory. Routine anterior posterior views are taken and occasionally oblique views to demonstrate multiloculation, encircling of the urethra, and extension beneath the trigone. If the cavity is filled with blood clots and exudate, or if the orifice is occluded, it will not be visualized.

The treatment is essentially surgical and consists of removal through the vagina. If contracted, the external meatus and urethra must be enlarged by incision and dilatation.

Six illustrative cases are presented.

CHARLES R. PERRYMAN, M.D.

THE BLOOD VESSELS

Arteriography of Peripheral Vessels. Technical Details. J. R. Learmonth. Lancet 2: 745–746, Dec. 9, 1944.

Arteriography is used to demonstrate the anatomical arrangement of the peripheral artery tree; the presence of local irregularities in caliber, in arteriosclerosis or Buerger's disease; thrombotic blockage of main trunks in obliterative vascular disease; the extent of collateral circulation; the site and extent of arterial aneurysms; and the site of arteriovenous fistulae. This paper calls attention to the use of this procedure for the last three purposes.

Arteriography should not be a routine procedure in investigation of the complications of arterial wounds. Clinical examination often gives the information required, and final details usually are to be obtained only by careful dissection. Arteriography may be useful, however, in determining the surgical approach in lesions involving the profunda femoris, the popliteal artery, and the beginning of the anterior and posterior tibial arteries, the opaque medium being introduced into the common or superficial femoral artery according to the clinical indications.

The author recommends a spinal anesthetic to remove all vasoconstrictor influences. When the lesion involves the femoral or profunda artery, the patient lies with his leg straight and rotated slightly laterally. When the popliteal is involved, the thigh is slightly flexed, abducted and everted, and the knee bent 20°, its lateral aspect being supported on the table by a sand-pillow. The apparatus used has been a mobile ward set (Watson), 90 kv., 30 ma., fitted with a Machlett grid tube; focus-film distance 30 inches; 12 × 10-in. film, double intensifying screens without grid. With 60 kv. and 50 ma. for femoral and 55 kv. and 50 ma. for popliteal arteriograms, the exposure is 0.3–0.4 second, according to the thickness of the limb. For the injection, an incision is made in the line of the vessel, either in Scarpa's triangle (for femoral-profunda) or in Hunter's canal (for popliteal) without raising the artery from its sheath. Diodone (perabrodil) 50 per cent is used, warmed to body temperature, and a 10-c.c. syringe with an eccentric nozzle and a No. 19 needle. The needle is passed into the artery, bevel downwards and parallel to its wall, to prevent leakage of blood during its passage and provide a long valvular tunnel which will be rapidly closed by intra-arterial pressure when the needle is withdrawn. When blood appears in, or is aspirated into, the syringe, the injection is rapidly completed (less than five seconds). The exposure is made when the injection is almost complete. The needle is then withdrawn, and a moist gauze swab pressed on the vessel at the site of puncture. Pressure is maintained until the film has been developed. If the film gives the required information, the wound is closed. If the lesion has not been demonstrated, a film may be placed more distally and the procedure repeated. Complications are rare. If there is no contraindication, the patient may be out of bed in forty-eight hours.

An editorial on "Limb Arteriography" appearing in the same issue of *Lancet* (page 757) carries an extensive bibliography.

FOREIGN BODIES

Localisation of Foreign Bodies. James F. Brailsford. Lancet 2: 749–751, Dec. 9, 1944.

Brailsford deplores the attempted surgical removal of foreign bodies after merely preliminary and often misleading roentgenography. Roentgen examination for the detection of foreign bodies is advisable for every wounded part, whatever its nature and appearance. A metal indicator, preferably a straightened safety-pin, is fixed to the skin so that its point indicates the wound. True anteroposterior and lateral views of the part are taken with the beam centered over the point of the pin. Suitably exposed films should be "flat" enough to show the outlines of the soft tissues as well as structures of the bones. In some cases, especially in wounds involving the skull and chest, it is advisable to have an additional roentgenogram, with the central ray directed at a tangent to the bony surface nearest to the foreign body. Fluoroscopy should not be a routine procedure, but is useful as a rough guide to the positions of those foreign bodies whose removal is deemed advisable. Localization of foreign bodies should be so accurate that the time taken by the surgeon in removing them, and the operative damage to the patient's tissues, are reduced to the minimum. Quick methods of localization are likely to be misleading, particularly when the

essential need for operating in the localizing position is overlooked. Moreover, they give little help in estimating the relative positions of the foreign body and anatomical features.

Construction of a Contact Lens for Localization of Intraocular Foreign Bodies. William P. McGuire and Edward C. Raffetto. U. S. Nav. M. Bull. **43**: 1239–1242, December 1944.

The authors describe a practical method for construction of a contact lens for intraocular foreign body localization, using dental materials. An alginate-base powder type of material is used for making the impression of the cornea and immediately surrounding portion of the sclera. This should show a definite corneoscleral junction. The impression, after being fixed, is used to make a stone cast and the actual lens is made on this cast with the use of a clear acrylic resin. The lens is polished and placed on the eye, and four points are marked at the corneoscleral junction in the 12, 3, 6, and 9 o'clock positions. Small holes are drilled through these points and are filled with silver amalgam alloy to make them radiopaque. The eye is anesthetized with 2 per cent butyn sulfate solution and the completed lens is applied. Care should be taken that the four points lie on the corneoscleral junction. Two roentgenograms are made: one anteroposterior, with the forehead and tip of the nose touching the film, and the tube angled 30 degrees toward the feet; the other a true lateral view through the orbits with the affected eye next to the film. For both views, the patient must look straight ahead with the unaffected eye.

For localization on the anteroposterior view, a base line is drawn through both superior orbital margins. The opposing amalgam points of the lens are connected by lines on the film. The intersection of these lines determines the center of the cornea. From this intersection, a line is drawn to the foreign body and projected to the base line. From this, the distance of the foreign body from the center of the cornea and the exact meridian in which the foreign body lies can be determined. On the lateral film, a vertical line connecting the two most widely separated amalgam points is drawn. This gives the plane of the limbus and from this, the location of the foreign body, with respect to the limbus, can be determined.

BERNARD S. KALAYJIAN, M.D.

TECHNIC

Rapid Roentgenography in the Operating Room. W. L. Minear. J. Bone & Joint Surg. **27**: 157–158, January 1945.

The author has constructed a portable developing tank and dark compartment to use in the operating room, in which concentrated commercial liquid developer is used. At 85° F. the developing time is one minute. The regular "hypo" is used. A diagram of the developing compartment is presented.

JOHN B. MCANENY, M.D.

X-Ray Technic for Diagnostic Films with the Weber Dental Machine Model-5. Lester D. Bibler and Douglas W. White. U. S. Nav. M. Bull. **44**: 170–171, January 1945.

The authors describe technical factors for use with the Weber Dental Unit Model-5. They have taken satisfactory films of the pelvis, lumbar vertebrae, ribs, lung, shoulder, and extremities with kilovoltages ranging between 32 and 45; milliamperage from 10 to 15, and time from $^3/_4$ to 2 seconds. They found, by experimentation, that the exposure factors given in the Weber manual produced overexposed films, and they recommend that, since there are slight variations in each machine, some experimentation be done to obtain the desired results, though the chart included in the article has proved satisfactory in most instances.

BERNARD S. KALAYJIAN, M.D.

RADIOTHERAPY

Supervoltage (One Million Volt) Roentgen Therapy at Walter Reed General Hospital. Milton Friedman. S. Clin. North America **24**: 1424–1432, December 1944.

A million-volt x-ray apparatus was installed at the Walter Reed General Hospital in February 1944. Based upon that hospital's experience, the author concludes that million-volt roentgen therapy is superior to lower voltage radiations in the treatment of malignant lesions.

1. It produces more effective destruction of the neoplasm by virtue of the greater quantity of effective radiation that can be delivered to the tumor with each treatment. As a consequence, the total number of treatments and the duration of the course of treatments are materially reduced.

2. The relatively mild immediate and late skin reactions reduce the discomfort to the patient and permit the administration of larger quantities of radiation through the skin. The increased depth dose to the tumor is attended by an increased incidence of damage to the adjacent normal tissue. This is a calculated risk which is outweighed by the beneficial effects on the tumor.

3. A number of lesions which were formerly considered "radioincurable" may now be considered as "radiocurable."

4. A number of lesions which were efficiently treated with 200 kv. radiation can be more efficiently and effectively treated with 1,000 kv. radiation.

The million-volt machine at Walter Reed Hospital, which, according to the author, is the smallest and most compact in the United States and is as flexible and mobile as any modern 200-kv. machine, is described. Photographs are included.

Treatment of Inoperable Cancer of the Throat (Follow-Up of Previous Report). M. F. Arbuckle, A. C. Stutsman, and Sherwood Moore. Ann. Otol. Rhin. & Laryng. **53**: 689–698, December 1944.

The authors describe a "new fundamental principle in treatment of carcinoma of the throat worked out by them in an attempt to avoid x-ray injury to the thyroid cartilage and the deadly complications which follow such injury. It consists in removal of the thyroid cartilage prior to the institution of roentgen irradiation." This account follows a preliminary report based on cases published in 1941 (South. M. J. 34: 219, 1941). At the time of their earlier paper the authors ...

unaware of the work of Hautant along similar lines, but credit is given him here (Hautant: Ann. d. mal. de l'oreille, du larynx 46: 1198, 1927; Flurin and Magdeleine: Ibid. 46: 1219, 1927).

Eighteen cases are presented in tabular form, with the dates of treatment (except in 4 cases) and the results. The patients were seen in the wards of the county and city hospitals and in the authors' practice. All had typical late generalized cancer of the throat with lymph node involvement, cachexia, and interference with deglutition, respiration, and phonation, accompanied by pain and weight loss. All were without possible hope of cure by surgical means. In some the original site of the lesion was the larynx; in others the epiglottis, and in still others the base of the tongue or laryngopharynx. In one or two the cancer had apparently started in the hypopharynx, and in one woman the lesion involved and blocked the mouth of the esophagus. In nearly all cases the cancer had spread to the neck, involving the lymph nodes and the thyroid gland. In most of the males some constitutional disease was an added difficulty.

In spite of these unfavorable circumstances, the authors are able to report 8 patients living and free of signs of cancer, with normal deglutition and a good voice. One of those still living was treated in 1936. The follow-up period for the others is shorter, being less than a year in some instances. Nearly all the survivors have a normal airway but wear a small tracheotomy tube, which they keep plugged. All cases were proved microscopically and graded according to the degree of cellular differentiation. All types, including well differentiated and poorly differentiated, were present. The type apparently had no influence on the response to irradiation. No attempt at surgical removal of the tumor was made.

Incision for removal of the thyroid cartilage is made in the mid-line from the level of the hyoid bone down to the fourth tracheal ring. A tracheotomy tube is inserted through the third and fourth rings. The outer perichondrium and the thyroid cartilages are divided in the mid-line, with care not to open the inner perichondrium, and complete subperichondrial elevation, outer and inner, is done. The cartilage is then lifted out with forceps and the wound closed in layers. Care is required while splitting the partially calcified thyroid cartilage to avoid injury to the cricoid cartilage.

In the cases reported, roentgen therapy was instituted about ten to thirty days after operation, the Coutard technic being used. In the 7 cases for which details are given, the total dosage ranged from 1,200 to 3,600 r to each side of the neck.

Close co-operation between the surgeon and the radiologist is imperative in order that the dosage be properly controlled. Dosage sufficient to kill cancer cells is invariably accompanied by skin burns and x-ray sickness. Local signs, usually referred to as mucositis and epidermitis, and a constitutional reaction evidenced by vomiting, prostration, dehydration, failure of appetite, rapid weight loss, or exacerbation of serious constitutional disease, are warning signals.

STEPHEN N. TAGER, M.D.

Chemotherapy and X-Ray Radiation in Treatment of Cellulitis of the Head and Neck. Samuel S. Wald. U. S. Nav. M. Bull. 43: 1200–1204, December 1944.

The author describes the treatment of cellulitis of the head and neck following extraction of lower third molars. He states that the patients may be very ill, with a temperature as high as 105° and diffuse hard indurated swelling of the face and neck including the lymph nodes in the neck. Sulfathiazole and x-ray therapy were used in most of these cases. When sulfa drugs were contraindicated, penicillin was used without x-ray therapy. When sulfathiazole was not tolerated, sulfadiazine was substituted. An attempt was made to maintain high blood levels of the sulfa drug used until the temperature and symptoms subsided, an average of seven to ten days. The x-ray therapy used was 150 r every other day for three treatments (120 kv.p., 25 cm. distance, and 2 mm. aluminum). A few patients were given one additional treatment, but a total of 600 r was not exceeded in any of the 100 treated. In addition to the chemotherapy and irradiation, abundant fluids, hot wet dressings, intra-oral irrigation, and sedatives were employed. Only very occasionally was it necessary to resort to surgical drainage.

The author gives a detailed report of one case in which numerous attempts at surgical drainage were made, with eventual production of a chronic suppurative lesion which did not respond to penicillin therapy but did respond well to sulfa medication plus x-ray therapy.

BERNARD S. KALAYJIAN, M.D.

Exit Dose in Dermatologic Roentgen Therapy. George C. Andrews, Carl B. Braestrup, and Eldred B. Heisel. Arch. Dermat. & Syph. 50: 355–360, December 1944.

A series of studies was made by the authors to determine the exit dose of low-voltage x-rays for various parts of the body. The dosage was measured by a roentgenometer with a small thimble chamber. All measurements were made at a target-skin distance of 30 cm. with a circular field 24 cm. in diameter. Three different voltages were used: 60 kv. and 100 kv. with no filter, and 135 kv. with 3 mm. Al.

The parts studied were the hands, feet, and face. The hands were placed on a treatment table with the thimble chamber beneath it between the third and fourth metacarpals. Care was taken that the thimble chamber was not placed under the bone. The beam was then directed through the dorsum of the hand. The feet were studied in the same manner, the thimble chamber being placed between the third and fourth metatarsals. Studies at the ala of the nose were made by pressing the thimble ionization chamber between the nose and cheek and giving a side exposure.

Measurements of the exit dose were taken on the hands of 40 patients. It was found that the average exit dose was 17.5 per cent of the air dose at 65 kv., 30.5 per cent at 100 kv., and 60 per cent at 135 kv. with 3 mm. Al. When 75 r in air is given to both sides of a hand, the total skin dose is 94 r at 65 kv., 109 r at 100 kv., and 133 r at 135 kv. with 3 mm. Al.

From these calculations, it can be shown that if 100 r is to be given to both surfaces of the hands, the air dose should be 80 r at 65 kv., 70 r at 100 kv., and only 55 r at 135 kv. with 3 mm. Al.

A chart is included with the article showing the exit dose at the three voltages in relation to the thickness of the hand. At 65 kv. there is a marked drop in exit dose as the thickness of the hand increases; at 100 kv., only a very moderate drop, and at 135 kv. with 3 mm. Al, very little change is seen.

The same findings obtained in studies of the hand were seen in studying dosages of the feet and face. The

authors conclude that the use of 60 kv. (half-value layer, 0.7 mm. Al) has definite advantages over higher-voltage irradiation. JOSEPH T. DANZER, M.D.

Tissue Dose Estimation in Combined Roentgen and Radium Therapy for Carcinoma of the Uterine Cervix. William E. Howes. New York State J. Med. 44: 1563–1568, July 15, 1944.

The method used at the Brooklyn Cancer Institute for estimating the tissue dose in combined roentgen and radium therapy for carcinoma of the uterine cervix is described. Diagrams showing two specific geometric arrangements of radium sources are used as a basis for determining the radium dosage to certain theoretic fixed points in the pelvis. The dose in gamma roentgens is arrived at in accordance with tables representing roentgens per milligram hour delivered to these points. For the roentgen dosage a depth dose graph is drawn up from actual measurements of each patient.

RADIATION EFFECTS

Post-Irradiation Bone Changes. F. R. Gratzek, E. G. Holmstrom, and Leo G. Rigler. Am. J. Roentgenol. 53: 62–76, January 1945.

Since November 1940, at the University of Minnesota Hospitals, routine pelvic roentgenograms have been made, before treatment and at yearly intervals thereafter, in all cases referred for deep roentgen therapy of malignant tumors of the pelvis. In addition, all patients treated since 1936 have been recalled and examined roentgenologically for evidences of injury to the pelvic bones. Twenty-five instances of bone necrosis or spontaneous fracture were discovered in 19 patients.

During the period 1936–41, 568 female patients were treated with irradiation for malignant tumors of the internal genitalia. Eighteen had serious bone sequelae, an incidence of 3.2 per cent. In one patient, signs of necrosis appeared almost six years after completion of the radiation therapy. In 541 male patients treated for carcinoma of the bladder or prostate, no fractures or other bone sequelae which could be assigned to the irradiation were encountered. Possible factors in producing the striking difference in sex incidence are the differences in anatomy (the same factors which produce traumatic fractures three times more often in females than in males), the more restricted fields of radiation often used in the treatment of carcinoma of the prostate, and the shorter life span of the latter patients after irradiation.

The quantity of radiation applied is undoubtedly an important factor contributing to the subsequent bone changes. The incidence of bone lesions is said to have increased appreciably after the institution of more intensive therapy. Radium application is thought to play a minor role.

The authors' series included 13 fractures of the femoral neck in 11 patients (2 bilateral); 2 cases of multiple fractures of the pelvis, in one of which a fracture of the femoral neck developed later; 8 cases of definite sclerosis or areas of necrosis in the head or neck of the femur (1 bilateral); 1 case of sclerosis of the right ilium with fracture of the pubic rami.

In no instance did the authors find fractures or necrosis in patients wholly free from symptoms, and in several cases there were well developed symptoms of bone involvement before changes were visible on the roentgenogram. While evidences of necrosis usually appear only after an interval of six to eight months, 2 cases were encountered in which roentgen changes were demonstrable within five months.

Fractures of the femoral neck are preceded by sclerotic changes. Careful study of the trabeculae will reveal areas of increased density in most instances. Especially significant is the appearance of a transverse line of density across the femoral neck; the head of the femur becomes more dense, and areas of rarefaction then appear. A similar course is observed in the acetabulum. These progressive changes resemble those of osteochondritis in the femoral head and of post-traumatic aseptic necrosis and caisson disease and point to an origin in vascular alterations.

In general the prognosis of radiation changes in the bones is fairly good, many excellent recoveries having been observed, with little disability.

The authors have tabulated the principal features in their 19 patients and report 8 of the cases in greater detail, including the 3 with multiple fractures of the pelvis involving the sacrum and pubic rami.

A case of retardation of bone growth resulting from irradiation of the soft tissues of the thigh in infancy is also reported. A review of the literature is given.

CLARENCE E. WEAVER, M.D.

Study by the Newer Renal Function Tests of an Unusual Case of Hypertension Following Irradiation of One Kidney and the Relief of the Patient by Nephrectomy. Archie L. Dean and Jules C. Abels. J. Urol. 52: 497–501, December 1944.

A 20-year-old female with normal blood pressure and apparently normal kidneys was irradiated in the left upper quadrant for a growing tumor which was thought to be lymphosarcoma or Hodgkin's disease. She received 3,000 r to an anterior and posterior portal with complete disappearance of the mass. Seven years later, headache and hypertension in the neighborhood of 184/125 developed.

Urine concentration tests and phenolphthalein excretion revealed no significant difference between the two kidneys. With more refined methods, however, which measure glomerular filtration, tubular absorption, and rate of blood flow through the kidneys, the left kidney was found to be markedly deficient in all. Mannitol clearance was used to measure glomerular filtration, while sodium para-amino-hippurate clearance was used to determine renal blood flow and tubular damage. Vascular lability was poor.

Following the removal of a sclerosed left kidney, the blood pressure and vascular lability returned to normal, and the function of the remaining kidney may have improved according to the newer renal function tests.

DAVID KIRSH, M.D.

RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

Vol. 45 OCTOBER 1945 No. 4

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RADIOLOGY

A MONTHLY PUBLICATION DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

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RADIOLOGY is entered as second class matter at Syracuse, New York, and Easton, Penna., under the Act of August 24, 1912, and accepted November 24, 1934. RADIOLOGY is published by the Radiological Society of North America as its official Journal. Subscription rate $6.00 per annum. Canadian and foreign postage, $1.00 additional. Single copies, 75¢ each. All correspondence relative to business matters connected with the Radiological Society of North America and RADIOLOGY, or remittance for non-member subscriptions, should be made payable to the Radiological Society of North America and should be addressed to the SECRETARY-TREASURER, DONALD S. CHILDS, M.D., 607 MEDICAL ARTS BUILDING, SYRACUSE 2, NEW YORK. In requesting change of address, both the old and the new address should be given.

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Vol. 45 OCTOBER 1945 No. 4

Osteoid-Osteoma of Bone[1]

HENRY L. JAFFE, M.D.

Director of Laboratories, Hospital for Joint Diseases, New York City

An osteoid-osteoma is a small, oval or roundish, nidus-like benign neoplasm of bone. When well advanced in its evolution, it consists, in varying proportions, of osteoid, trabeculae of newly formed osseous tissue, and a substratum of highly vascularized osteogenic connective tissue. The lesion usually does not exceed a centimeter in its greatest dimension, and in a given affected bone may lie within the spongiosa (perhaps at or near an articular surface), or against the inner surface of the bone cortex, or even actually within the cortex. Though the nidus-like focus is the osteoid-osteoma *per se*, the total abnormal area in the affected bone may be very large, since there may be a perifocal zone of bone thickening or sclerosis extending for a considerable distance beyond the nidus. The lesion is a distinctive one, and we hold that it represents an entity *sui generis* in the pathology of bone disease.

CLINICAL CONSIDERATIONS

To date, we have in our files the data (including roentgenographs and pathologic material) on 62 proved cases, representing, with few exceptions, patients treated in the Hospital for Joint Diseases (New York). Of these 62 cases, 5 formed the basis of our first report (1) on the condition in 1935; 28 represent the cases which accumulated between that time and 1940, when we made our second report (2); the remaining 29 have accumulated during the five succeeding years. It is interesting to note that in general the statistical relations in regard to sex and age incidence and location of the lesions are essentially the same for the total series of 62 cases as for the 33 which had accumulated up to 1940.

Of the total 62 patients, 42 were males and 20 females. There seems now to be little room for doubt that the disorder predilects males.

As to the age incidence, the new cases confirm the finding that osteoid-osteoma has a predilection for adolescents and young adults. We have age records on 59 of the 62 patients. The accompanying table shows the distribution, by five-year

Age	No. of Cases
1 to 5	4
6 to 10	2
11 to 15	15
16 to 20	17
21 to 25	14
26 to 30	5
31 to 35	1
36 and over	1
TOTAL	59

[1] Delivered Feb. 16, 1945, before the New England Roentgen Ray Society and the Boston Orthopedic Club. Accepted for publication in March 1945.

periods, of the ages of these patients at the time of admission for removal of the lesion. The youngest patient was aged a year and a half and the oldest forty-nine years. It is striking that all but 13 of the 59 were between eleven and twenty-four years of age.

The lesion may appear in a limb bone or in one of the bones of the vertebral column, and a clear-cut instance of its occurrence in an innominate bone has been reported (3), though the present writer has not personally encountered it there.[2] Furthermore, it would not be surprising eventually to find it in a skull bone or a rib. The following table lists the various bones affected and, in descending order of frequency, the number of times each was found to be involved among the total 62 cases. As this table also shows, the bones of the lower limbs are much more commonly affected than those of the upper, and in half the cases the lesion was in a tibia or a femur.

Bone Involved	No. of Cases
Tibia	17
Femur	14
Fibula	6
Humerus	5
Vertebrae	4
Astragalus	3
Phalanges (pedal)	3
Phalanges (manual)	2
Ulna	2
Calcaneum	2
Radius	1
Patella	1
Tarsal navicular	1
Ankle region (site not precisely given)	1
TOTAL	62

The duration of complaints at the time of admission for removal of the lesion ranges between a few months and a number of years. Histories of less than six months are the exception; of six months to two years, the rule; and of over two years, not common. Only one patient gave a history of difficulties dating back as long as five years.

Clinically, the principal complaint is of pain, and it was this that consistently led the patients to seek medical attention. Occasional and mild at first, the pain usually increases in persistence and severity and often becomes bad enough to interfere with sleep. Sooner or later, local swelling is apparent in some instances, particularly if the lesion is in a bone site not very thickly covered by soft tissue. Limping is complained of by a considerable number of patients in whom a lower-limb bone is involved. Stiffness and weakness of the part are observed in some cases—notably those in which the lesion is near a joint. In none of our cases was there a history of febrile episodes in connection with the lesion.

Physical examination often reveals a sharply localized point of tenderness somewhere in the painful area. Also, as already noted, there may be some local swelling. These are frequently the only relevant clinical findings. In some cases, on account of the fact that the part has been spared in use, there may also be a slight amount of muscle atrophy. Only rarely does one note even slight local heat and redness and, indeed, these were present in only one of our 62 patients.

A definite majority of the patients (about 70 per cent) did not relate the onset of their complaints to an antecedent local trauma. Some of those who did so relate it stated that the trauma had preceded the onset of symptoms by weeks, months, or even years. The others dated the onset of the complaints directly from the injury. Since, however, only about 30 per cent of the patients brought up the factor of trauma at all, and it was in only about half of these cases that the alleged injury was directly inculpated, we are not inclined to regard trauma as an etiologic factor.

Clinically, the diagnosis of osteoid-osteoma is not very difficult if one is

[2] Since submitting this manuscript for publication, the writer has been afforded the opportunity, through the kindness of Dr. Leo Mayer, of studying personally an osteoid-osteoma which had appeared in an innominate bone of a girl of seventeen and was located just below the anterior inferior spine, extending down almost to the acetabulum.

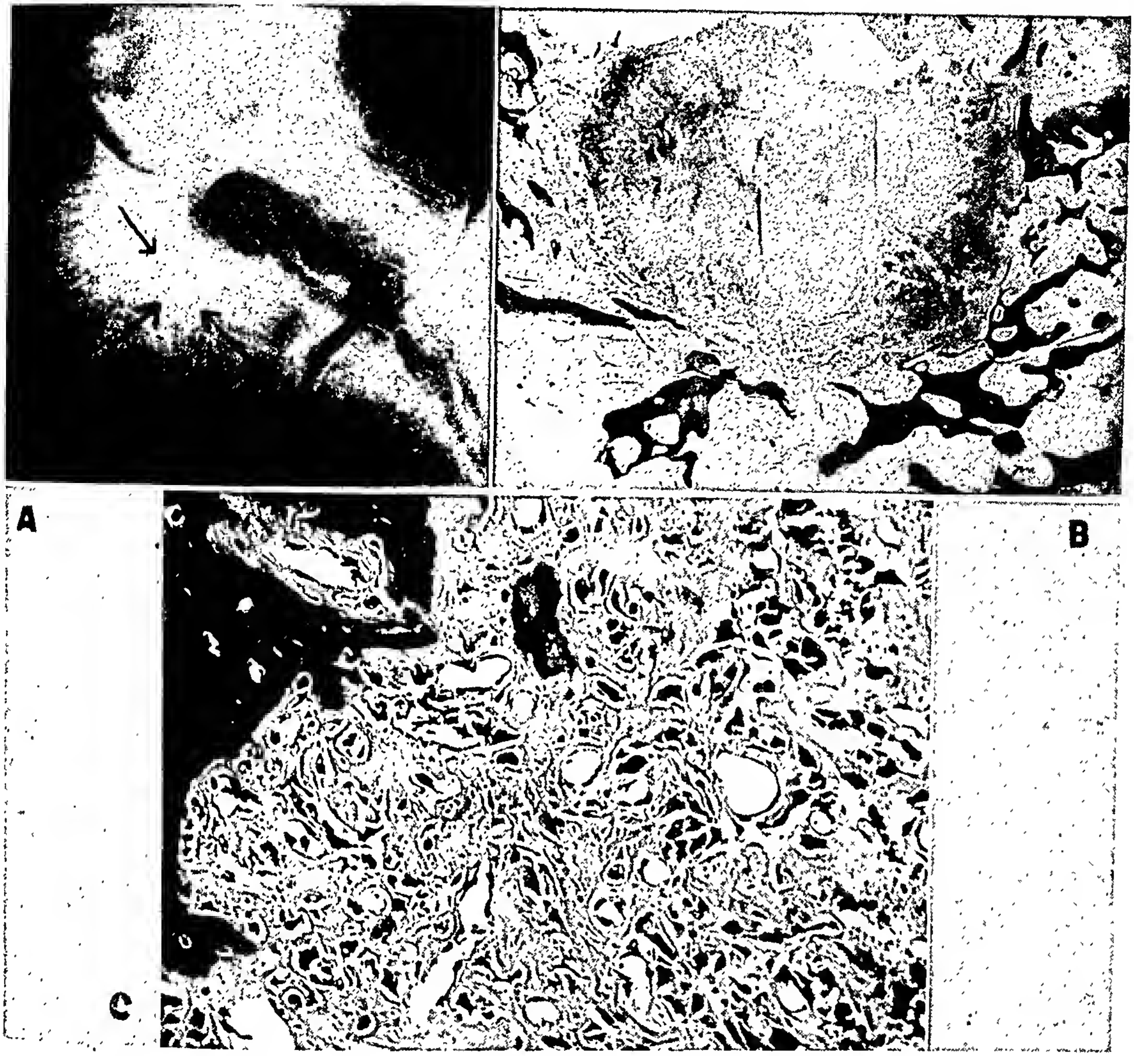

Fig. 1. Case 1. A. Preoperative roentgenograph showing an area of relative radiolucency (corresponding to the osteoid-osteoma) surrounded by an irregular zone of radiopacity. B. Photomicrograph (×10) showing a full cross-section of the osteoid-osteoma standing out clearly against the neighboring bone. The magnification is too low to reveal details of the histologic architecture. C. Photomicrograph (×250) showing cytologic details in one area of the periphery. One can note that the vascular osteoid tissue has undergone bony transformation in some places.

familiar with it, if the possibility of its presence is borne in mind, and if the lesion has advanced sufficiently in its evolution to be demonstrable roentgenographically. The history and physical examination alone often furnish the necessary clues, although it is the roentgenographic picture that constitutes the most valuable single diagnostic guide. In a suspected case presenting a characteristic roentgen picture, the affected bone shows the nidus as a small oval or roundish, relatively radiolucent or (less frequently) radiopaque area. The nidus shadow is often (though by no means regularly) surrounded by a more or less opaque or dense shadow reflecting the reactively thickened or altered zone of neighboring bone. This dense area of perinidal reaction may be only a narrow ring or it may spread for several centimeters about the lesion, even if the latter is in the spongiosa. If the nidus appears in relation to the bone cortex, the reactively densified area may extend for several inches both above and below. The densification of the cortex may also be found to extend for a considerable distance around the circumference of the affected shaft

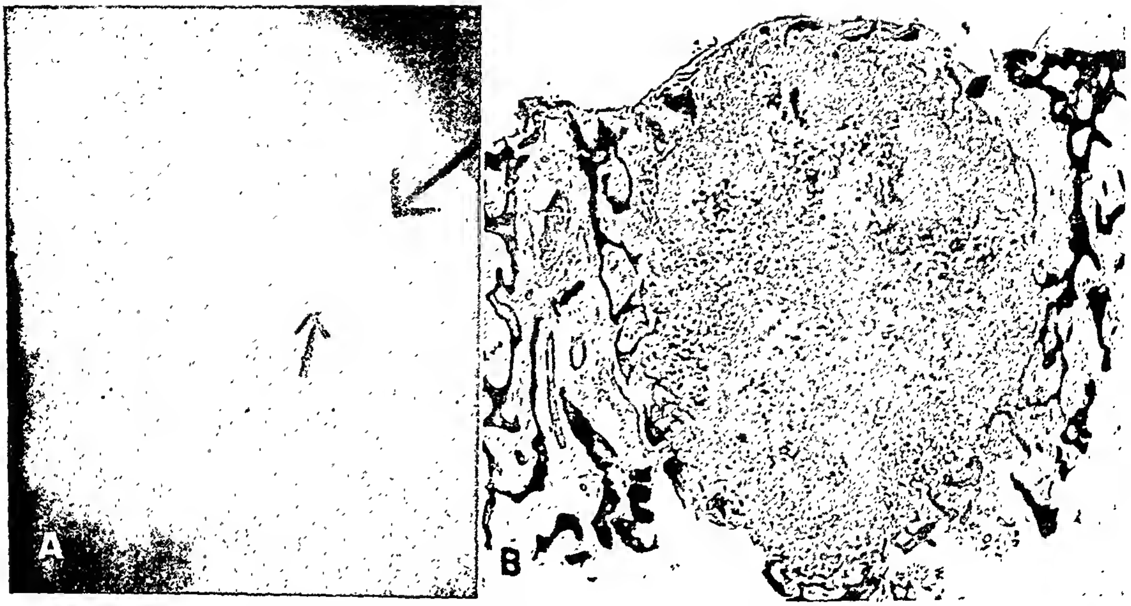

Fig. 2. Case 2. A. Roentgenograph showing the osteoid-osteoma in the neck of the astragalus, as it appeared four months before it was removed surgically. B. Photomicrograph (×10) of the osteoid-osteoma with some of the neighboring bone. Though details of the cytology are not revealed under the low magnification, it is clear even from this picture that the cytologic architecture is not uniform throughout the lesion.

area. Altogether, these are x-ray pictures which the many roentgenologists and orthopedists who accept osteoid-osteoma as a condition *sui generis* have come to know and recognize as representing it. For additional comments on the roentgenographic picture, see p. 326.

Not all cases of osteoid-osteoma, however, are easily recognizable when first coming under medical care. The diagnostic difficulty may be due to the fact that the lesion has not yet evolved sufficiently to be identifiable roentgenographically, or to its obscure location, or to both factors simultaneously. Understanding of the subject can probably best be advanced at this stage by sketches of a number of recent cases which, for one reason or another, presented diagnostic problems.

CASE REPORTS

CASE 1 (Fig. 1): A man of 24, a fourth-year medical student, was admitted to the hospital, under the care of Dr. Leo Mayer. His chief complaint was of pain in the right foot, just anterior to the external malleolus, of sixteen months' duration. He stated that it had begun in August 1940, either before or after he had twisted his right ankle, that at the start it had been only occasional, and that it was aggravated by protracted activity. Two months later, at his school, he first came under medical care for the condition. At that time, the roentgenograph of the ankle region was reported as negative, and the region was strapped. About five months after its onset, the pain began to occur at night, often interfering with sleep. The patient then noticed some swelling of the ankle and severe pain on eversion of the foot. Soon afterward, the pain became continuous, and he began to limp. A short leg plaster with a walking iron was applied, but failed to bring relief. After that, another plaster casing was applied which did not permit weight-bearing, and the patient used a crutch, but again there was no relief. About ten months after onset of the complaints, the foot was again examined roentgenographically and again reported as showing no positive findings. At this time, on the assumption that the patient had a chronic synovitis of the peroneal tendon sheath, the area was explored, but a biopsy specimen taken from the sheath shed no light on the condition.

During the subsequent six months before he consulted Dr. Mayer, the patient began to be regarded as a psychoneurotic. On examination, it was now found that the foot was held in slight internal rotation and slight inversion. There was weakness of the evertors of the foot. The lateral surface of the os calcis, just anterior to the external malleolus, showed slight swelling, and this region was exquisitely sensitive to pressure. There was also tenderness of the os calcis, just anterior to the swelling. The roentgenograph now taken showed a round, somewhat radiolucent nidus about 5 mm. in diameter, surrounded by a narrow perifocal zone of sclerosis and located in the os calcis somewhat below the subastragaloid joint. On removal, the

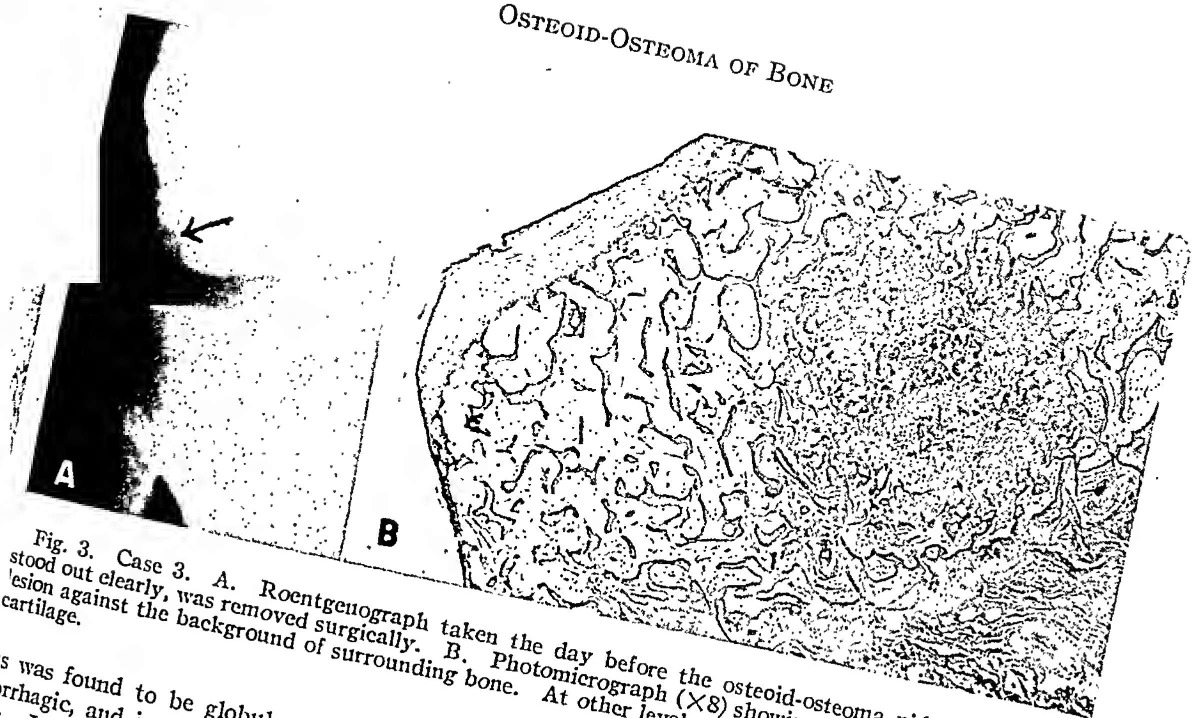

Fig. 3. Case 3. A. Roentgenograph taken the day before the osteoid-osteoma nidus, which now stood out clearly, was removed surgically. B. Photomicrograph (×8) showing a full cross-section of the lesion against the background of surrounding bone. At other levels, the lesion extended to the articular cartilage.

nidus was found to be globular in shape, in part hemorrhagic, and in part yellowish and somewhat gritty. Its removal was followed by prompt, dramatic, and permanent relief from all the local complaints, as was reported by Dr. L. J. Barron (4) in the *Bulletin of the Hospital for Joint Diseases*.

Case 2 (Fig. 2): A boy of 11 was admitted to the hospital, under the care of Dr. Samuel Kleinberg. His complaint, which was of pain and disability relating to the left ankle region, was then of one and a half year's duration, dating back to July 1942. The onset of his difficulty was rather sudden and was not preceded by any known trauma. Two months afterward, the patient first consulted Dr. Kleinberg, who, on the basis of the history and physical examination, suspected even then that an osteoid-osteoma was present in the astragalus, though the roentgenographic findings at that time were equivocal. Shortly thereafter, the patient was transferred to the care of another orthopedic hospital. There it was suspected that he was suffering from tuberculosis of the astragalus, in the vicinity of the astragalo-calcaneal joint. The area in question was explored, but nothing significant was found. Some synovium was taken for histologic examination but yielded no positive findings. The foot was then kept in a brace for about six months, but there was no subsidence of the complaints. About fifteen months after the onset of symptoms, a roentgenograph clearly revealed, for the first time, a lesion considered to be an osteoid-osteoma, which, however, was located in the superior portion of the neck of the astragalus. Nevertheless, the foot was kept in a plaster-of-Paris bandage for an additional four months, still without subsidence of the complaints. The patient was then returned to the care of Dr. Kleinberg.

Examination just prior to surgical intervention for the osteoid-osteoma showed that the ankle region was much swollen and that there was considerable tenderness to pressure over the anterior aspect of the foot in the region of the astragalus. Also, the bones of the foot were extremely atrophic on account of the protracted immobilization. Motions of the ankle were painful and restricted, and the patient favored the area very much in walking. At operation, the diseased area in the neck of the astragalus was resected in one block, measuring 1.5 × 1.5 cm. and up to 1 cm. in thickness. On its upper surface, the block presented a round, slightly elevated, reddishly discolored area measuring 1 cm. in diameter. On transection, the nidus was clearly seen as a globular mass about 1 cm. in diameter, in part reddish and in part whitish and calcareous, surrounded by a small rim of spongiosa. The excision was immediately followed by complete subsidence of the local complaints.

Case 3 (Fig. 3): A woman 49 years of age, admitted to the hospital under the care of Dr. Kleinberg, stated that she had had pain in the left knee for the past two years, specifically since about November 1938. It had begun insidiously, without any known antecedent injury or illness. It was mild and intermittent at first, but soon became continuous and severe, causing disability and interfering with sleep. It was only on the day before admission that the patient first consulted Dr. Kleinberg. She told him that in the previous two years roentgenographs of the knee had been made many times and that its condition had been diagnosed as arthritis. Indeed, many teeth had been extracted on the assumption that root infections were responsible for the articular difficulty.

In his study of the patient, Dr. Kleinberg found

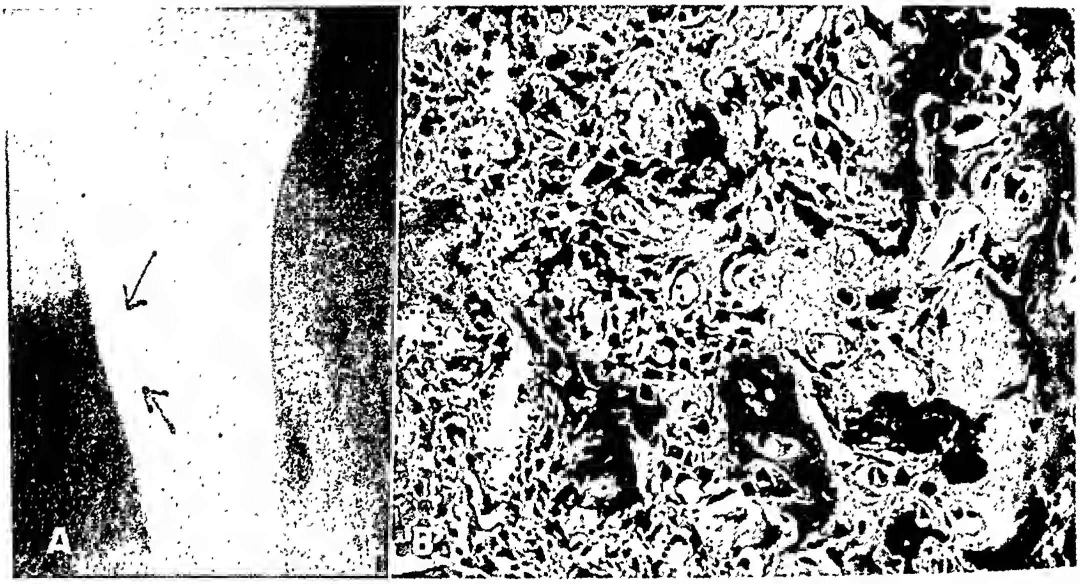

Fig. 4. Case 4. A. Preoperative roentgenograph showing the osteoid-osteoma nidus in the upper end of the cortex of the humerus, on the medial side. B. Photomicrograph (×250) showing tissue from the osteoid-osteoma which was sectioned without decalcification. Note the vascular osteogenic connective-tissue substratum, containing osteoid which is undergoing calcification and thus bony transformation in some places.

that she walked with a limp on the left side, but that the knee was freely movable and showed no local heat or excessive articular fluid. The circumference of the calf was an inch less on the affected leg than on the other. The patient pointed to one spot on the antero-external surface of the lower end of the femur as the center of the pain, and at this site there was exquisite tenderness to pressure, limited to an area about 1/2 inch square. The presence of an osteoid-osteoma was suspected. A roentgenograph taken on admission to the hospital showed a nidus-like focus of abnormality at the lateral margin of the external condyle, extending almost to the articular cartilage. Restudy of the roentgenographs which had been taken elsewhere during the preceding two years showed, in some, an analogous abnormal focus, which, however, because of its lack of conspicuousness, might easily have been overlooked.

The area in question, with some of the neighboring bone, was excised in one block. This consisted of a small wedge of the external condyle of the femur, lined on one surface by a bit of articular cartilage, beyond which the cortex continued. Shining through the periosteum, in the vicinity of the cartilage-cortex junction, was a basically gray, reddishly discolored nidus-like area, oval in shape and about 7 mm. in its greatest diameter, which bulged the periosteum and was located in the spongiosa. Removal of the osteoid-osteoma was promptly followed by relief from all the difficulties, as Dr. Kleinberg notes in his account of this case (5).

CASE 4 (Fig. 4): A girl 20 years of age was admitted to the hospital, under the care of Dr. Harry Sonnenschein. She stated that for the past two years (since about December 1941) she had been having pain in the upper part of the right arm and shoulder region, and that, though there was no pain in the elbow, there was also pain in the forearm and wrist, down to the base of the fingers. The pain was dull, nagging in character, constantly present, and definitely worse at night, but was not affected by activity or by changes in the weather. It usually yielded to aspirin but was sometimes so severe that morphine was needed for relief. The patient also stated that the right hand had been perspiring more than the left and that occasionally she felt a sensation of coldness in the hand in question. However, there were no differences between the two hands in respect to skin color or temperature. Also, there was a full range of painless motion in all the joints.

Though the sweating of the hand was held to be incompatible with a scalenus anticus syndrome, the clinical impression created by the case as a whole was that the complaints had a neurological basis. The patient was seen by two neurologists, neither of whom found anything to sustain the diagnosis of a scalenus anticus syndrome. Note was taken, however, of wasting of the right supraspinatus and infraspinatus and anterior serratus muscles. One of the neurologists obtained the impression that the complaints might be related to an occupational neurosis; the other suggested spinal-fluid studies to determine the possibility of a cord lesion.

Roentgenographic studies of the chest, cervical spine, and right shoulder girdle were all negative except in regard to the upper portion of the shaft of the right humerus. There it was noted that the cortex, somewhat below the neck of the humerus, on one side was thickened and sclerotic and pre-

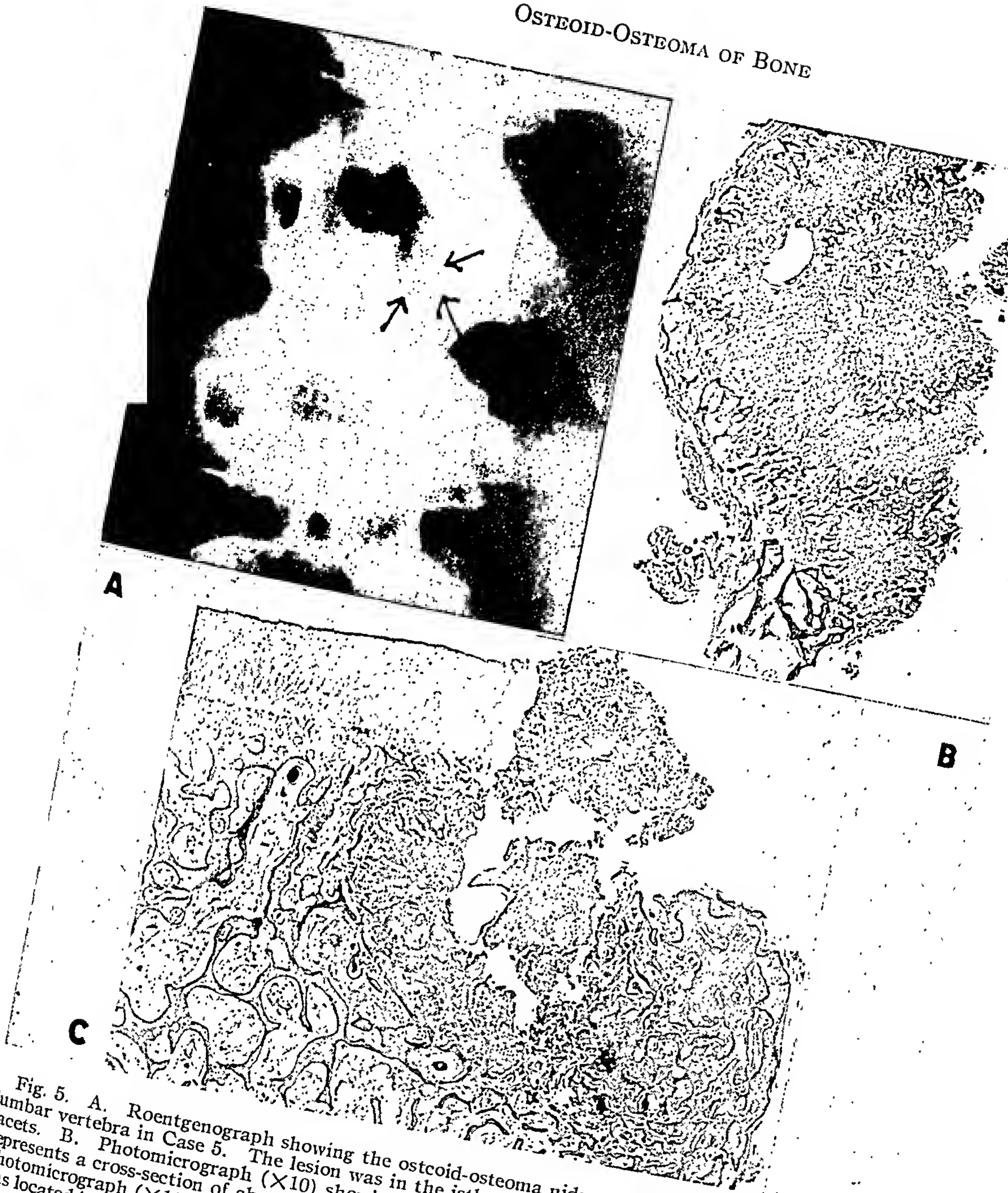

Fig. 5. A. Roentgenograph showing the osteoid-osteoma nidus on the right side of the second lumbar vertebra in Case 5. The lesion was in the isthmus, between the ascending and descending facets. B. Photomicrograph (×10) showing part of the lesional tissue that was removed. This represents a cross-section of about half of the lesion, which broke in the course of its removal. C. Photomicrograph (×10) from another case of osteoid-osteoma in a vertebra. Specifically, the lesion was located in the left descending facet of the second lumbar vertebra, and the illustration shows how clearly the lesional tissue stands out from the unaffected bone area.

ented an oval-shaped focus of relative radiolucency bout 1 cm. in its longest axis. Because this was e only abnormality ascertainable, the area was ucerized and the material sent to the laboratory. nong the many pieces of cortical and spongy bone ived, were two bits of gritty, brownish tissue ch, on histologic examination, were found to be parts of an osteoid-osteoma nidus. The intervention promptly relieved the patient of her pain, and within a few days all the complaints for which she entered the hospital had subsided, not to recur.

CASE 5 (Fig. 5): A girl of 10 was admitted to the hospital, under the care of Dr. Samuel Kleinberg. For ten months (since August 1942) the child had had pain in the back. Previously, she had been under care at another hospital, where she was treated first with exercises, then with traction on a convex frame, and finally by encasement in plaster of Paris. Examination on admission here revealed a mild, rounded fullness of the paravertebral region on the right side, at the level of the 1st and 2d lumbar vertebrae. Though palpation did not elicit any

tenderness over the spinous processes of these vertebrae, there was exquisite tenderness just to the right of the mid-line in this region. A roentgenograph taken on admission revealed a small area of abnormality involving the upper aspect of the lamina of the 2d lumbar vertebra on the right side. Though no definitive preoperative diagnosis had been made, exploration seemed advisable. At the site in question, the surgeon found a globular, red, partly soft and partly calcareous, cherry-sized focus of tissue, which was removed with part of the lamina from which it sprang. On examination in the laboratory this nidus-like focus was found to measure 7 mm. in its greatest diameter, and bits of similar tissue were found lining excavations of osseous fragments, representing parts of the lamina. Removal of the lesion (and local spinal fusion) was followed by disappearance of the complaints, which have not recurred to date.

COURSE IF THE OSTEOID-OSTEOMA NIDUS IS MISSED ON SURGICAL INTERVENTION

That the associated clinical complaints promptly and permanently cease when an osteoid-osteoma is removed, is illustrated by the cases we have just cited and by our total experience with the lesion. On the other hand, we know that if, in the course of the operation, the osteoid-osteoma is not removed or destroyed, the clinical complaints do not disappear. Two cases will suffice to illustrate this fact, one showing continuance and the other subsequent renewal of the complaints following the intervention.

The former patient was a man of 24, and the total period of complaint was four years at the time of admission to our hospital on account of an osteoid-osteoma of the shaft of the femur. Two years previously he had been operated upon at another hospital for what was believed to be an osteomyelitis at the same site, but, though some thickened cortex was removed, the nidus was not. The complaints continued after the operation and, indeed, were even more pronounced than before. They disappeared promptly and completely after the second surgical intervention, two years later, at which time the osteoid-osteoma nidus was removed.

In the other case—that of a boy of 13 years—the complaints were of six months' duration at the time of initial admission, and the osteoid-osteoma was in the neck of the femur, adjacent to the lesser trochanter. The surgeon attempted a block resection, hoping to remove the nidus intact in its setting. Unfortunately, as was revealed by anatomic examination of the specimen and by a postoperative roentgenogram, the nidus was left behind. The patient was free of complaints for about twelve months, but was readmitted about two months later (that is, about fourteen months after the first admission) with essentially the same complaints he had had originally. At this time, the osteoid-osteoma nidus was really removed, and at the last follow-up, a year and a half after the second intervention, the patient was still free of his osteoid-osteoma complaints (Fig. 6).

PROBLEMS OF ROENTGENOGRAPHIC DIAGNOSIS

As already noted, it is roentgenographic study that constitutes the most valuable aid in the clinical diagnosis of osteoid-osteoma. Nevertheless, the diagnosis may present certain difficulties, even in cases in which the complaints are of long standing. Thus, if the affected bone area is much thickened, the nidus may fail to stand out against the surrounding bone if insufficient kilovoltage is used in the exposure of the film. This was found to be particularly true in a number of cases in which the lesion was related to the cortex of a long bone. Under ordinary conditions of exposure, all one noted was blurry thickening of the affected bone area. However, when the field had been coned down upon, and the picture had been taken with a good deal of overexposure and in different planes, the osteoid-osteoma nidus stood out clearly.

In cases in which the complaints are of recent date, it may be difficult to demonstrate the osteoid-osteoma nidus even under favorable technical conditions. This probably explains, in part, why the large majority of the patients under consideration did not enter the hospital for removal of the lesion until a year or more after

Fig. 6. Case in a boy of 13, in which the osteoid-osteoma nidus was not removed at the first operation. A. Preoperative roentgenograph, showing, though indistinctly, the lesion in the neck of the femur, adjacent to the lesser trochanter. B. Roentgenograph taken shortly after the operative intervention, showing that the block of bone resected did not include the osteoid-osteoma, the latter now showing up much more distinctly than before. C. Roentgenograph taken fourteen months after the original surgical intervention—that is, just prior to the second surgical intervention for removal of the nidus. D. Photomicrograph (×13) showing a cross-section of the osteoid-osteoma nidus that was removed at the second operation.

onset of their complaints. Indeed, iany of these cases, roentgenographic amination of the painful bone area had en done previously (usually elsewhere) it failed to yield any illuminating findgs, and it was only the picture taken ortly before admission that revealed the lesion. Thus, in a suspected case not confirmed by the original x-ray examination, re-examination should be done at intervals of a few months, since it may ultimately confirm the diagnosis, as it did in some of our series.

In respect to the shadow cast by the

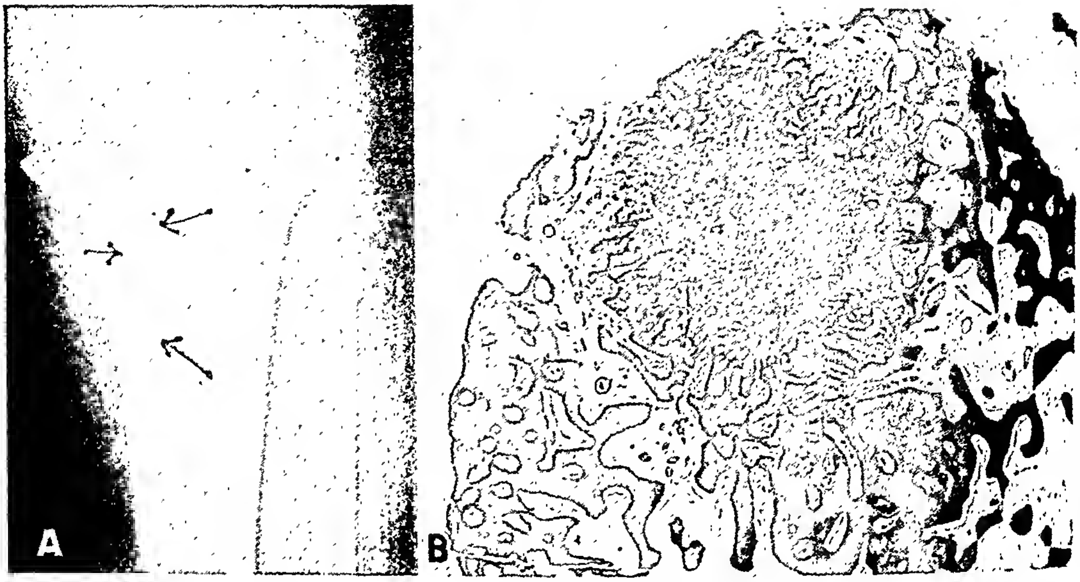

Fig. 7. A. Roentgenograph of an osteoid-osteoma in an early stage of evolution, developing in the cortex of a tibia posteriorly. The patient was a child of 2 1/2 years who complained of pain below the knee for only three months before admission to the hospital. An osteoid-osteoma evolving in the cortex of a bone and presenting this roentgenographic appearance (not observed until recently and hence not illustrated in the previous articles) was noted also in 2 other of our cases, in which the lesion was also held to be in a very early stage of evolution. B. Photomicrograph (×10) showing a cross-section through the lesion. Note the sharp delimitation of the latter from the surrounding cortex.

osteoid-osteoma nidus at various stages of its evolution—that is, in respect to its relative radiolucency or radiopacity in relation to the bone neighboring upon it—the author's opinion has undergone a change which calls for comment. Previously (2), it was stated that an osteoid-osteoma nidus which appeared relatively radiolucent represented the lesion in an early stage of its evolution, and a nidus which appeared relatively opaque represented a late stage of evolution. On the basis of further experience and recorrelation of the anatomic with the roentgenographic findings in all of our material, the opposite seems to be nearer the fact. Thus, we now believe that when an osteoid-osteoma nidus appears as a relatively radiolucent round or oval area surrounded by a zone of radiopacity, the lesion is likely to be one which has reached its fullest development, while in the earlier stage of its evolution the nidus tends to cast a relatively radiopaque shadow.

If one is dealing with a nidus in an early stage, especially if the surrounding bone has undergone thickening or sclerosis, the two shadows may even merge and be indistinguishable, and the difficulty of diagnosis of some of the cases while still in an early stage of evolution may stem from this fact. On the other hand, if one is dealing with a nidus in the early stage of its evolution but the surrounding bone has not undergone much sclerosis, the nidus may stand our clearly as a focus of radiopacity. We have seen 3 cases of this kind in which the evolving early lesion was etched out with striking clarity as a small rod-shaped focus against the neighboring bone (Fig. 7).

DIFFERENTIAL DIAGNOSIS

There is no doubt that cases of osteoid-osteoma are still often interpreted as localized bone infection, and specifically as Brodie's abscess, intracortical bone abscess, or even the so-called "sclerosing non-suppurating osteomyelitis of Garré." Indeed, in a paper entitled "Solitary Eccentric (Cortical) Abscess in Bone," published in the October 1943 issue of *Surgery*, Brown and Ghormley (6) reject the concept of osteoid-osteoma. They maintain in particular that the lesions of the kind which we would call osteoid-osteoma

Fig. 8. Case 1A. A. Preoperative roentgenograph of the tibia of a woman of 42 who was suffering from an intracortical bone abscess. From the x-ray picture and from the clinical findings one might have suspected an osteoid-osteoma, but the clinical history was not characteristic of the latter lesion. B. Photomicrograph (×8) showing a full cross-section of the abscess, which is located in the interior of the original cortical bone. The thickening of the cortex is due to periosteal new bone apposition. C. Photomicrograph (×250) showing the abscess wall heavily infiltrated with polymorphonuclear leukocytes.

oriented to the cortex of the affected bone are nothing more than solitary cortical bone abscesses. They also imply that lesions which we would call osteoid-osteomas oriented to the spongiosa of a bone are nothing more than solitary medullary abscesses (*i.e.*, Brodie abscesses).

Study of their paper, however, shows the following: In the first place, of their 24 cases, supposedly of solitary bone abscess, only 14 came to surgery and were hence susceptible to anatomic confirmation. Furthermore, while the roentgenographic picture is given in 6 cases (4 of which I would accept as probable instances of osteoid-osteoma on the basis of the picture) none of the 3 photomicrographs given relates to any of these 6 cases. In addition, of the 3 photomicrographs, only 1 presents a picture clear enough to be

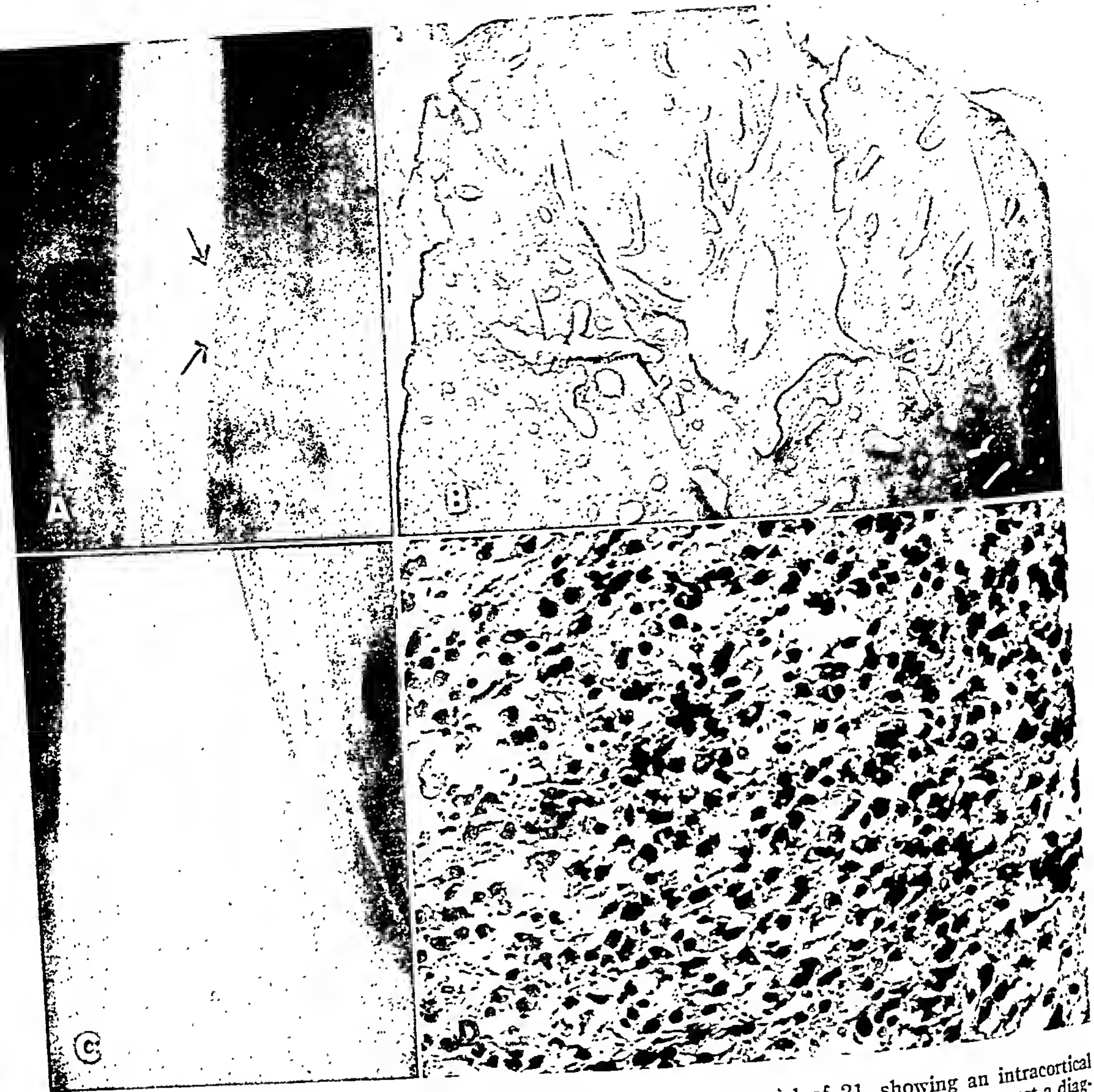

Fig. 9. Cases 2A and 3A. A. Roentgenograph of a fibula of a girl of 21, showing an intracortical abscess (Case 2A). In this case, neither the clinical history nor the clinical findings could support a diagnosis of osteoid-osteoma. B. Photomicrograph (×10) showing, in the cortex of the fibula, the abscess which is extending to the surface of the bone and which is lined by a thick connective-tissue membrane found to be heavily infiltrated by leukocytes. C. Roentgenograph showing a lesion in the lower metaphysis of a tibia of a boy of 13 (Case 3A) who was admitted for treatment of a solitary intramedullary bone abscess (Brodie abscess). In this case, neither the roentgenographic findings nor the history and clinical findings would support a diagnosis of osteoid-osteoma. D. Photomicrograph (×250) showing the character of the granulation tissue occupying the interior of the abscess cavity in this case.

confidently interpreted at all on a pathologic basis. That picture plainly shows evidences of rather acute infection, and though, as already stated, the x-ray picture in this case is not given, one can be satisfied, with the aid of the legend, that the authors were dealing in that instance with a bone abscess rather than an osteoid-osteoma.

That localized bone abscesses exist, the writer has never denied. These abscesses may be purely intracortical, they may be intracortical and subperiosteal, or intracortical and medullary, or they may be purely medullary. In anatomic appearance, they bear no resemblance whatever to the osteoid-osteoma lesion. Clinically, too, most examples of solitary bone abscess (cortical or intramedullary) bear little resemblance to cases of osteoid-osteoma. though roentgenographically a solitary bone abscess sometimes resembles an osteoid-osteoma. Indeed, it is purely because a cortical bone abscess may re-

semble roentgenographically an osteoid-osteoma with cortical orientation, that Brailsford (7) interprets the latter as a chronic subperiosteal abscess.

I shall now present 3 cases of bone abscess in which the anatomic findings, especially, speak for themselves as to the difference of this lesion from osteoid-osteoma.

CASE 1A (Fig. 8): The patient was a woman of 42, complaining of attacks of dull, aching pain in the middle of the right leg, appearing at night and lasting only until morning. These had been noted at monthly or bimonthly intervals for the past two years, especially. The anterior surface of the middle of the tibia was thickened over a small area, but the overlying skin was not adherent, abnormally warm, or reddened.

CASE 2A (Fig. 9, A and B): A girl of 21 complained of localized swelling, of three weeks' duration, on the outer aspect of the left leg. Trouble with this leg had begun about a year before, when apparently a bite or scratch had become infected. In the interim, however, the manifestations of acute local infection had subsided, and now all that was apparent clinically was the swelling associated with thickening of the soft tissues over the middle region of the fibula.

CASE 3A (Fig. 9, C and D): A boy of 13 was admitted because of sudden exacerbation of pain and swelling of the right ankle, which had been noticed from time to time during the past two years. The ankle region was swollen, tender, and warm, and the clinical impression was that the condition was a bone abscess.

Another source of diagnostic difficulty may arise under the following circumstances: A patient may have pain localized to some bone or joint area in which roentgenographic examination reveals a focus of radiopacity suggesting an enostosis. In such a case, there is danger that the enostosis may be misinterpreted as an osteoid-osteoma and believed erroneously to be the source of the pain. The speaker has seen several cases in which this situation created a practical problem of differential diagnosis. The absence of sclerosis or thickening of the bone about the enostosis, and of point tenderness over it, should help to distinguish it from an osteoid-osteoma.

Finally, in the course of roentgenographic study of a joint area, one may encounter in one of the constituent bones a small focus of radiolucency which may superficially suggest an osteoid-osteoma and mistakenly be held responsible for complaints, but which actually represents merely a small, nondescript fibrous nodule or even a cyst in the bone, the complaints having some other cause.

THE NATURE AND GENESIS OF OSTEOID-OSTEOMA

On the basis of the additional experience we have had with osteoid-osteoma since 1940, the writer still feels full confidence in affirming that this lesion of bone is a lesion *sui generis*. As to the reaction of others to this conception, it must be said in advance that only a meager literature has accumulated on the subject. The authors of the relevant reports fall into three main groups in respect to their opinions about the lesion. There are those, including Mallory (8), Stauffer (9), Lewis (3), Bado and Larghero-Ibarz (10), and our colleagues, Kleinberg (5), Horwitz (11), and Barron (4), who accept our concept of osteoid-osteoma. Others, including Mondolfo (12), Ottolenghi (13), and Brailsford (7), though recognizing the anatomic distinctiveness of the lesion, nevertheless interpret it as representing a peculiar inflammatory tissue reaction in a bone, rather than a small, self-limiting neoformation, in accordance with our conception. Finally, there are Brown and Ghormley (6), who deny the distinctiveness of the lesion altogether and maintain that all so-called osteoid-osteoma lesions are only small chronic bone abscesses oriented either to the cortex or to the spongiosa of the affected bone.

Just as strongly as we have maintained that osteoid-osteoma is a lesion *sui generis* we have maintained that it cannot be held to have an inflammatory basis. We submit that comparison of the cases of osteoid-osteoma cited here with those of bone abscess is by itself convincing as to this point. We need not repeat the evidence against the idea that osteoid-osteoma may have an infectious-inflam-

matory basis, since it is fully given in our 1940 article written in collaboration with Lichtenstein (2). In that article, as well as in the article of 1935 (1), we also explain why we do not think that the osteoid-osteoma lesion represents a peculiar healing or reparative form of some familiar lesion or that it originates from an embryonic rest. Altogether, we have been led both by the process of elimination and by consideration of the anatomic characteristics of the lesion itself to the conclusion that it should be interpreted as a neoplasm, and specifically as a peculiar benign tumor of bone.

We are aware that there are certain features of the osteoid-osteoma which may be held to be inconsistent with such an interpretation. First among these are the small size of the lesion (usually not exceeding 1 cm. in greatest diameter) and its seemingly self-limited nature, irrespective of its duration. Then there is the fact that it tends to incite the formation of a perifocal zone of bone sclerosis or thickening, sometimes of considerable magnitude, especially when the lesion is developing in relation to the shaft cortex of a long bone. The fact, however, that anatomically, and especially microscopically, the osteoid-osteoma nidus, when well evolved, does have the characteristics of a neoformation seems to us to outweigh in importance these apparently inconsistent or contraverting features. The latter are frankly puzzling and require explanation, but they only emphasize the peculiarity of the condition as a whole.

We have also been puzzled by certain features of the pathology of the lesion itself, and especially by the problem of interpreting the evolutionary sequence of the pathologic patterns seen in the various specimens. This problem can be only touched upon here. The genesis of the lesion is, in general, much more difficult to trace as it appears in the spongiosa than as it appears in the cortex, since it apparently evolves more slowly in the latter. At the site in the cortex where the lesion is developing, an intense reconstruction and vascularization of the original cortical bone sets in, spreading from the vessel canals. The original cortical bone at the site is soon substantially broken up and resorbed, but is replaced by highly atypical osseous tissue deposited by the osteogenic connective tissue carried on the walls of the blood vessels which are invading the area. While this focus of cortex is undergoing creeping replacement, the overlying periosteum may be depositing a thick layer of new bone of rather normal architecture. A clearly delimited nidus of closely compacted trabeculae of highly atypical new bone with few residua of the original bone soon comes into evidence. Progressively, one notes an increase of vascularized osteogenic connective tissue between the compacted trabeculae of atypical bone, and these trabeculae are, in turn, replaced. What we come to see now at the affected site is what we interpret as the evolved lesion—that is, a highly vascularized substratum of osteogenic connective tissue undergoing osteoid and osseous metaplasia. When the writer coined the name of osteoid-osteoma, it was this advanced stage that he was designating and whose unique appearance he was trying to summarize.

TREATMENT

It is clear from what has already been said that surgical removal of the lesion is all that is needed to bring prompt and lasting relief from the complaints. The nidus and some of the neighboring bone may be removed by curettement, but this should be thorough, since otherwise there is danger of recurrence of the complaints. The only disadvantage of curettement is a purely scientific one—namely that the tissue may be so crumbled that, unless the pathologist or surgeon is thoroughly familiar with the condition, he may fail to pick out the significant fragments (representing the nidus) for histologic examination and thus fail to obtain confirmation of the clinical diagnosis. The writer, in acquiring his experience with the lesion, has sought, wherever possible, to obtain the nidus in-

intact in its setting so that he would be completely oriented in studying its pathologic anatomy. Indeed, resection of the lesion intact in its setting, if possible, remains the procedure best calculated to facilitate wider understanding of the condition while abolishing the complaints of the patient.

What the ultimate status would be in any of our cases had there been no surgical intervention at all, we do not know. It is noteworthy, however, that among our patients there were a few with complaints for as long as three or four years, and one in which they had been present for five years before the lesion was removed and relief ensued. Nevertheless, it is conceivable that an osteoid-osteoma might, after many years, undergo spontaneous clinical arrest or even anatomic involution. However, in view of the severity of the clinical complaints and the ready accessibility of the lesion, in most cases, for surgical removal, it will not easily be possible to collect information on this point. Nor do we know what irradiation therapy can do for an osteoid-osteoma in either an accessible or an inaccessible site.

SUMMARY

The lesion designated as osteoid-osteoma of bone is discussed on the basis of a total experience now covering 62 cases. The condition has a predilection for males over females in the proportion of about 2 to 1; it is found predominantly in older children, adolescents, and young adults; and, though it may affect almost any bone, shows a strong preference for the lower limb bones and especially the femur and tibia. On the basis of the wider experience, it is reaffirmed that the lesion is a highly distinctive one and an entity *sui generis* in the pathology of bone disease, and that it is to be interpreted as a benign tumor of bone, albeit a peculiar one. When well advanced in its evolution, the lesion consists, in varying proportions, of osteoid, trabeculae of newly formed osseous tissue, and a substratum of highly vascularized osteogenic connective tissue.

The lesion usually does not exceed a centimeter in its greatest dimension, and, in a given affected bone, may lie within the spongiosa (perhaps at or near an articular surface), or against the inner surface of the bone cortex, or even actually within the cortex. An osteoid-osteoma stands out from the surrounding osseous tissue as a sharply delimited nidus, but the total abnormal area in the affected bone may be very large, since there may be a perifocal zone of bone thickening or sclerosis extending for a considerable distance beyond the nidus.

In interpreting the roentgenographic picture in a case of osteoid-osteoma, one must remember that this picture has two aspects—the manifestation of the nidus or osteoid-osteoma proper and that of the reaction which it has incited in the surrounding tissue. When this picture is characteristic, the affected bone shows the nidus as a small, oval or roundish, relatively radiolucent or (less frequently) radiopaque area, often surrounded by a more or less opaque or dense shadow reflecting the reactively thickened or otherwise altered zone of neighboring bone. While persistent local pain and a sharply localized point of tenderness are useful indications in the diagnosis, it is the roentgenographic picture that constitutes the most valuable single diagnostic guide. Removal of the lesion is followed by prompt and lasting disappearance of the complaints.

In an attempt to convey a well rounded picture of the condition as one encounters it in individual instances, 5 recent cases are discussed in detail and illustrated. The presentation also includes a discussion of the differential diagnosis, especially from bone abscess.

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The Use of Radioactive Sodium as a Tracer in the Study of Peripheral Vascular Disease[1]

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THE EMPLOYMENT of various artificially radioactive elements as "tracers" has been reported in a considerable number of biological and physiological studies. Atoms of a radioactive isotope of any element are chemically indistinguishable and inseparable from atoms of its normal stable isotopes. If they are administered to a living organism, the result is the same as from administration of the stable isotope, unless such a large amount is given that the accompanying radiation produces an effect. Each radioactive atom, however, in disintegrating emits beta or gamma radiation (or both) which can be detected in various ways.

Any desired substance can thus be "tagged" by mixing with the stable atoms a relatively very small number of radioactive ones. The tagged atoms continue to be mingled with the normal ones administered at the same time, in the same proportions throughout their whole course through the body, except for radioactive decay, which can be allowed for if necessary. Hence, by determining the activity of a sample of tissue or excreta at any time after the administration of a labeled dose, the percentage of the recently administered material can be determined. Some substances emit such penetrating radiations that their presence in various parts of the living organism can be detected and measured.

Such an isotope is radioactive sodium, Na^{24}. Following its introduction into the body in any manner, its transfer by the blood and its arrival at any part can be observed by the use of a Geiger-Müller counter. In the studies to be reported in the present paper, a few cubic centimeters of normal saline containing the desired amount of the radioactive isotope were injected intravenously, and the circulation of the blood was traced by following the sodium it carried.

Studies of this type have now been carried out on more than 200 patients with peripheral vascular disease. The method provides a simple and objective means of determining the blood supply to an extremity through either the main arteries or collateral circulation. Since the viability of an extremity depends upon its blood supply, it is evident that any information on this subject should be useful in diagnosis, prognosis, and evaluation of therapy. In practice the observations obtained by this method have been especially helpful in demonstrating the competency of the collateral circulation when the main arteries are partially or totally occluded. This is valuable in determining the probable reparative powers of the tissues locally, the justification for continued local conservative surgery, the presence of sufficient arterial blood supply in a given region to warrant reasonable expectation of primary or secondary wound healing of an amputation site, and the degree of operative trauma which such a site might successfully tolerate. Repeated tests at intervals during a course of therapy (local or systemic), or following its completion, furnish a means of evaluating the treatment and thus of estimating prognosis. The method is simple, accurate, objective, and does not require hospitalization. The incidental dose of radiation delivered to the patient by the complete disintegration

[1] From the Departments of Surgery and Radiology, College of Physicians and Surgeons, Columbia University, New York City, with the aid of a grant from the Lilla Babbitt Hyde Foundation. Read before the Joint Meeting of the American Roentgen Ray Society and the Radiological Society of North America, Chicago, Ill., Sept. 24–29, 1944.

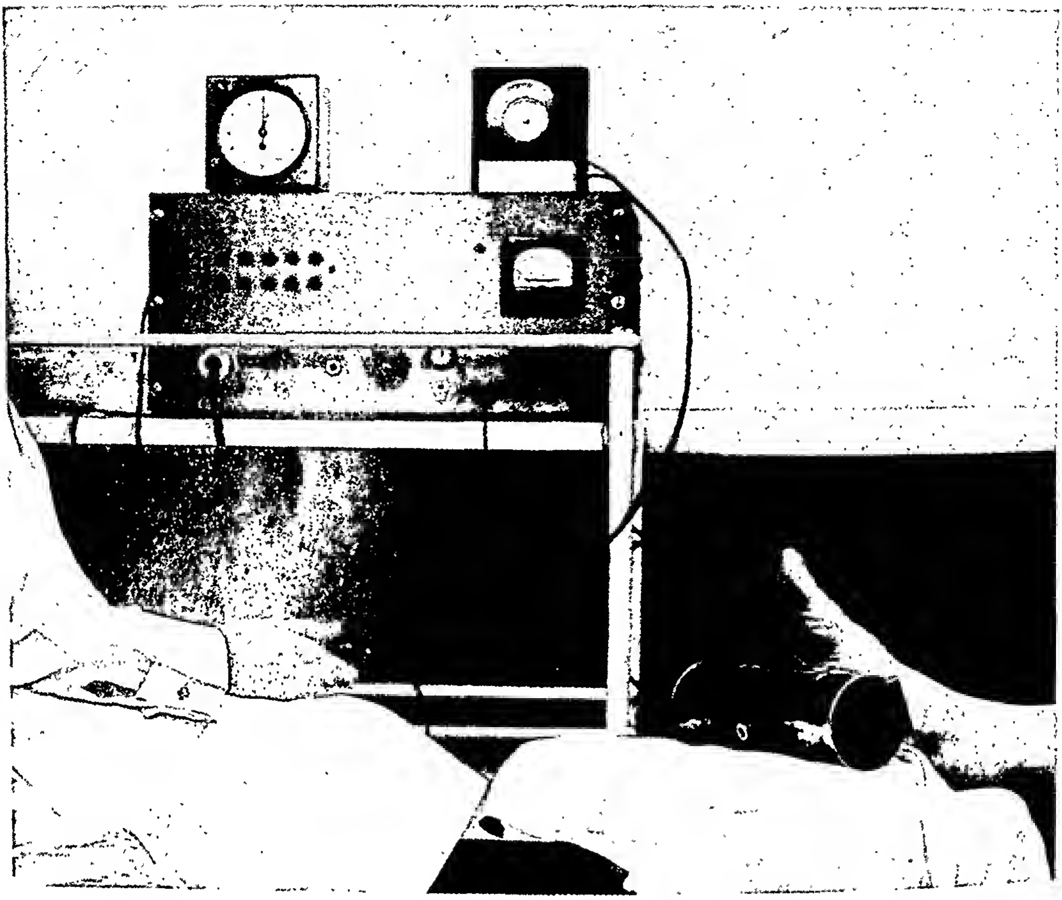

Fig. 1. Geiger-Müller counting tube, amplifier, and scaling circuit. The shielded tube is shown in position against the foot of a patient.

within his body of the administered radiosodium is considerably less than one roentgen.

The radioactive sodium is prepared in the cyclotron by bombarding sodium metaborate with deuterons. The metaborate containing the active atoms is dissolved in water, acidified with hydrochloric acid, and treated with methyl alcohol, resulting in the formation of methyl borate, sodium chloride, and water. The solution is evaporated to dryness and heated to remove excess acid; the material is then dissolved in pyrogen-free distilled water, to give the desired concentration for injection, and autoclaved for an hour.

The counting apparatus is shown in Figure 1. The Geiger-Müller counting tube is shielded in half an inch of lead except for a thin aluminum window 7 × 5.5 cm., which is placed against the region to be studied, as the patient lies comfortably in bed. Usually the study is started with the window of the counter against the distal plantar metatarsal region of a foot; the material is injected into an antecubital fossa vein, and thus arm-to-foot circulation time can be immediately established. Certain precautions are essential. The predetermined dose of the isotope—usually about 100 microcuries in 5–12 c.c. of solution—is drawn into an accurately graduated syringe, with care not to contaminate the outside of the syringe, the hands of the injector, or the environment of the patient. The needle must be secure on the syringe. With the syringe containing the material held close to the site of injection, the scaling device on the counter is adjusted so that one or two clicks are heard every five seconds. These are due to cosmic and other background radiation as well as to the radioactive isotope to be injected. When this background has been established, venipuncture is carefully done after the application of a tourniquet. A

9 to 22 gauge needle is used, depending n the size of the recipient's vein; care is aken to be sure that the bevel of the needle es entirely within the vein. The injecion and the electric stop clock are started multaneously, and counts are recorded very five seconds, the time of the end of he injection being also noted.

The arrival of the radioactive substance 1 the tissues in contact with the counter is gnaled by a definite increase in the countig rate. In normal subjects and in many ith vascular disease, the increase is arked and abrupt, but in some patients ith considerably lowered circulation it is o gradual that it is difficult to say just hen the material first arrived. It is for is reason that five-second counts are reorded, instead of reliance being placed olely upon auditory recognition of increased counting rate. The interval from tart of injection to time of arrival is armo-foot circulation time.

If the counter is left in position against he foot, and counting is carried on minute y minute, it is found that the count increases steadily and markedly for some ime. This should be expected as the reult of interchange of the injected radioodium between plasma and extravascular uid until equilibrium is established beween the two. The manner in which this quilibrium is built up depends on the rate f delivery of the isotope to the part by the xisting main and collateral circulations nd on the relation between the local inravascular and extravascular space; these epend on the normal or diseased condition f the extremity. The shape of the "buildp curve" gives valuable clinical informaion relative to the condition of the arterial essels maintaining the viability of the art.

Counts may also be taken at other posiions, such as calf, popliteal region, thigh. Comparison of counts at the same level 1 the two legs is useful in determining elative extent of the disease process.

The following types of case have been tudied: (*a*) normal, *i.e.*, young and niddle-aged persons who have normally palpable vessels and no history of vascular disease; (*b*) arteriosclerosis; (*c*) diabetes with arteriosclerosis; (*d*) thrombo-angiitis obliterans; (*e*) extremities subjected to freezing during a blizzard; (*f*) immersion foot in patients exposed in the ocean or in open boats following torpedoing of ships; (*g*) scleroderma; (*h*) essential hypertension; (*i*) varicose veins with edema and ulcerations; (*j*) arteriovenous fistula; (*k*) glomic tumor; (*l*) Raynaud's disease; (*m*) arteriosclerosis with peripheral multiple femoral aneurysms; (*n*) aneurysm of abdominal aorta; (*o*) hemangioma of lower extremity; (*p*) congenital hypertrophy of an extremity; (*q*) erythromelalgia; (*r*) hypertrophic osteoarthropathy; (*s*) deformed ulcerated edematous extremity in which no arteries could be palpated because of deformity and edema; (*t*) lymphedema. In some of these conditions only a single patient has been observed to date; in others, however, series of 10 to 15 cases have been studied.

TABLE I: CIRCULATION TIMES, ARM-TO-FOOT

Diagnosis	Number of Cases	Average Time, Seconds	Range, Seconds
Arteriosclerosis	24	45	20–105
Arteriosclerosis with diabetes	13	42	25– 90
Arteriosclerosis with diabetes and infection	5	27	20– 40
Thrombo-angiitis obliterans	12	33	20– 70
Scleroderma	5	44	15– 75
Chronic varicose ulcer	3	38	30– 45
Hypertension	13	41	20– 80
Post-frozen feet	6	43	25– 60
Miscellaneous	39	34	15– 75
Normal (no evident vascular disorder)	11	43	20– 55
All Cases	131	39	15–105

In Table I are presented the data on circulation time in 131 cases; the average value is 39 seconds, but the range is considerable. The highest, 105 seconds, was in an elderly arteriosclerotic; the lowest, 15 seconds, in a young man with a pulse of 100, suffering from scleroderma. In the arteriosclerotic groups and in hypertension there is considerable variation; in general, it can be said that slower times are associated with more advanced stages of dis-

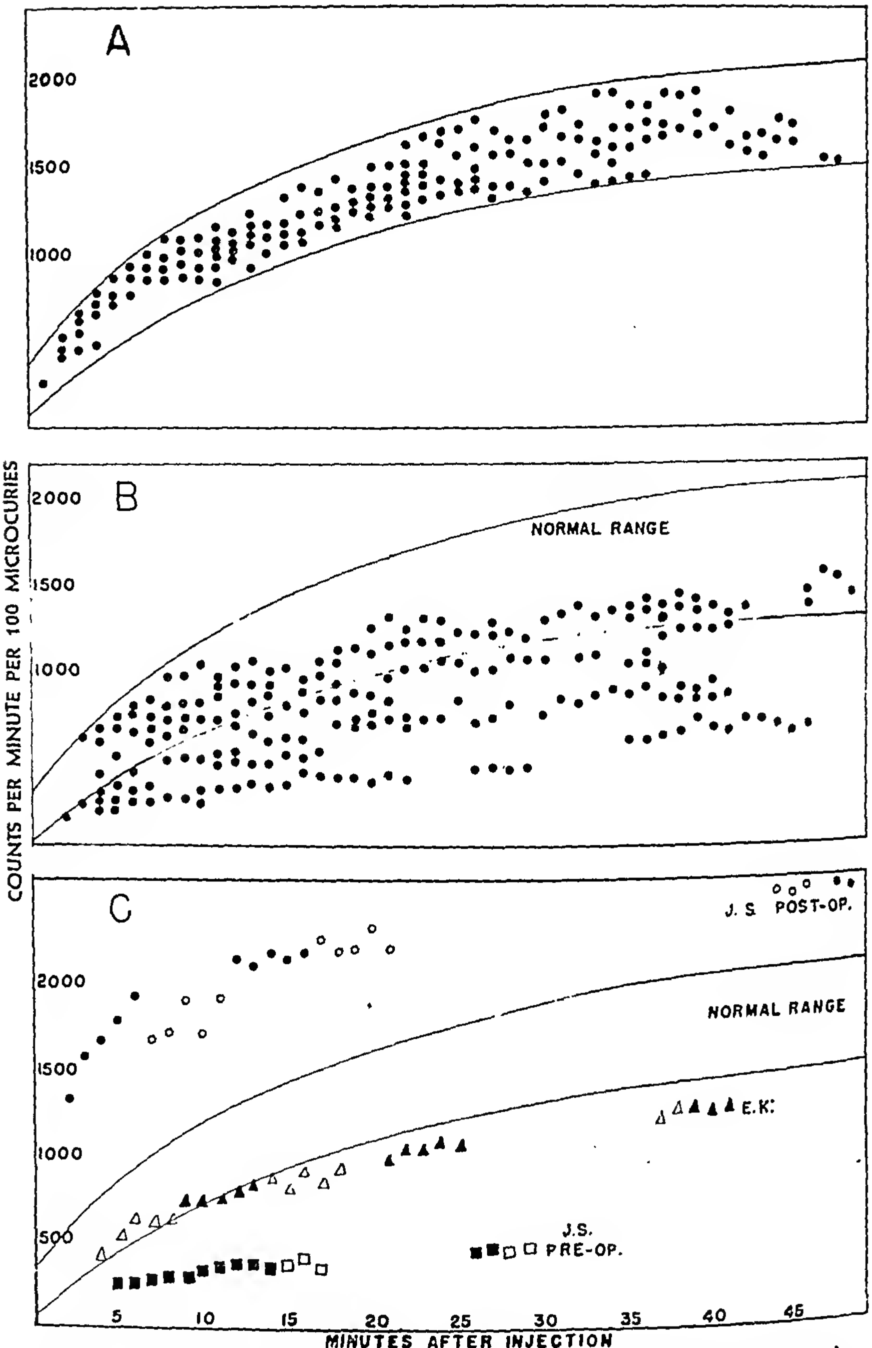

Fig. 2. Radiosodium build-up curves. A. Normal. B and C. Hypertension. For details see text.

ease. In normal subjects, and in other groups of pathological cases, the range is less.

More valuable than circulation time as a clinical aid is the curve of equilibrium build-up discussed earlier. Figure 2, A, shows data for 11 persons with no known vascular disease. Points represent counts per minute, per 100 microcuries injected; each point represents a count on one person at a definite number of minutes after injection. Where two or more points co-incided, only one can be shown, so that the actual number of points on the graph does not indicate the total number of observations. The subjects varied in weight from 116 to 193 pounds, in height from 5 to 6 feet, and in age from 14 to 45 years. No allowance or correction is made for any of these factors, in either the normals or the

iseased subjects. While there is consid-:able variation among individuals, it is ,ident that there is in all cases a rapid crease during the first few minutes, with slower increase thereafter to the end of ie chart. In no instance was there any fference between counts in the right and ft foot of a normal subject.

In Figure 2, B, are shown counts for 10 itients with essential hypertension. The nge here is much greater than for the rresponding group of normals just above. n the whole, these patients exhibit a ild-up curve lower than normal, only 2 the series remaining within the normal nge at the end of half an hour.

Two cases from the group of Figure 2, , are repeated in Figure 2, C, to illustrate fferent aspects of the disease. In this id all subsequent charts, closed or solid mbols represent counts at the right foot; ren symbols, counts at the left foot. Pa-:nt J. S. is a young woman without clini-:l or x-ray evidence of arteriosclerosis. er low preoperative curve is thought to ive resulted from peripheral vascular asm. Following bilateral thoracolumbar mpathectomy, the curve has ascended ell above the normal range. The patient is been, for the year following operation, mpletely relieved of her symptoms. No cent measurement of blood pressure is ailable as she is out of the country. Pa-:nt E. K., a middle-aged man, had evi-nce of peripheral sclerosis and nephritis addition to his essential hypertension. is curve is nearly normal, indicating little no spasm. He succumbed with cere-al hemorrhage four months after sym-ithectomy and before a postoperative dium study could be made.

Figure 3 presents data for patients with stemic and peripheral arteriosclerosis. igure 3, A, gives curves for 5 cases un-mplicated by other systemic diseases; ley are uniformly below normal except r the right foot of one person. This pa-ent is the only one of the group who has me to operation; he underwent bilateral nputation below the knee by modified uillotine technic for uncontrolled pain in the feet. Pathological examination of the nerves did not show ischemic neuritis, and it is a clinical presumption that his pain was the result of local anoxia, in spite of the high sodium reading (indicating reasonably good circulation). The wounds healed by primary union; rehabilitation with an artificial leg occurred two or three months after each operation.

Figure 3, B, shows data for two arteriosclerotics with severe diabetes, each having extensive infection in the right foot. The high counts for these right feet are attributed to the increased blood supply due to inflammation. The clinical condition in each of these patients was such that amputation seemed indicated. They were, however, treated by conservative surgery, with digital amputation only. Both are walking, with all toes off the right foot, some months after treatment. The high count, indicating abundant blood supply, is considered prognostic of good wound healing, even in the face of infection.

In Figure 3, C, are data for three patients with arteriosclerosis complicated by diabetes and with clinical evidence of diminished blood supply. All show low counts except the right foot of patient R. V., which is normal. She had gangrene of two toes on the left foot and underwent a modified guillotine amputation of the left leg below the knee. The wound opened and required subsequent grafting; four months after the amputation she was fitted with an artificial leg. Patient J. K., with a similar curve, showed healing following an amputation below the left knee. Patient I. M., in spite of low counts indicating restricted circulation, showed healing of an area of gangrene on the right great toe and of the second toe amputation site on the left foot. These patients are all well a year or more after treatment.

In Figure 4, A and B, are presented data for a group of patients with thrombo-angiitis obliterans. These are, in general, not far from the normal range. The three cases of Fig. 4, A, have done well following conservative surgery. Sodium tests in all these cases were two years or more post-

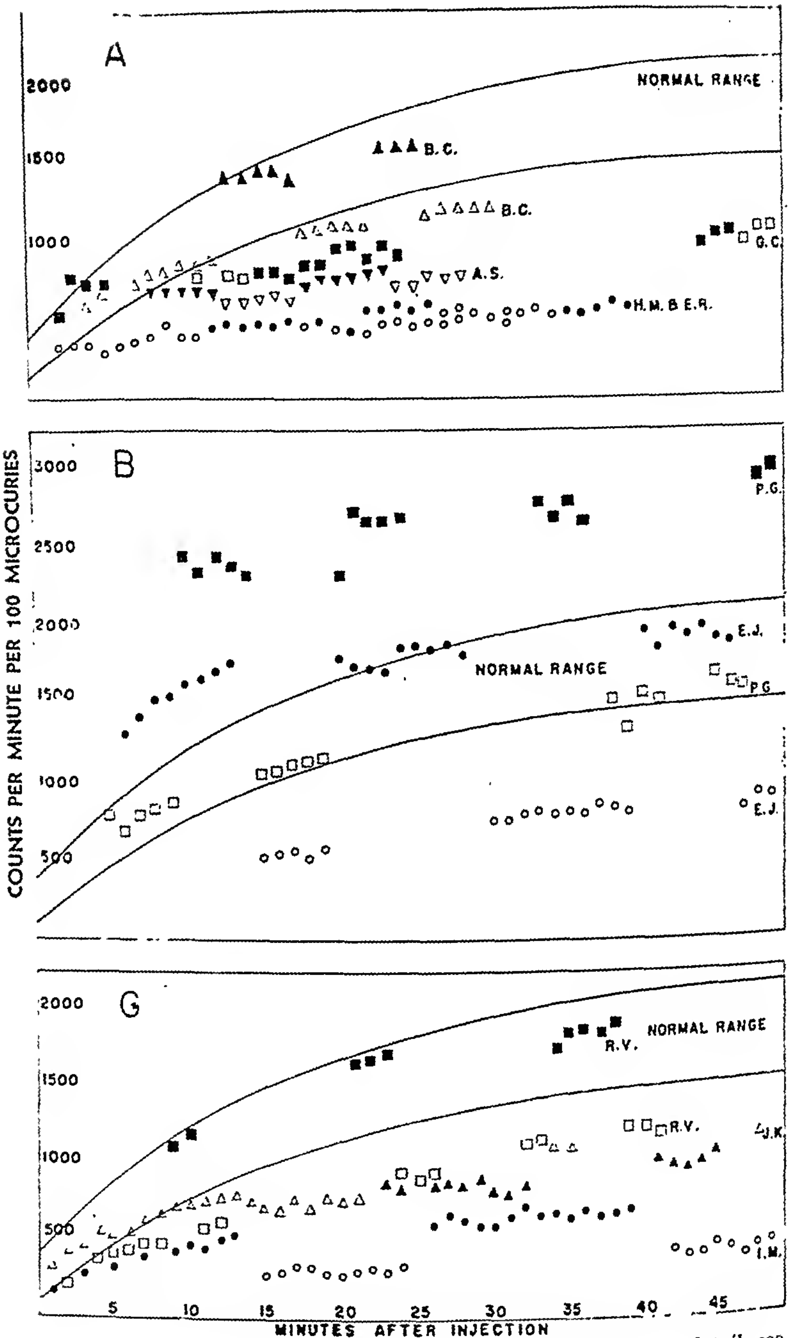

Fig. 3. Radiosodium build-up curves in arteriosclerosis. For details see text.

operative; in the two amputated cases (J. C. and R. S.) they indicate good blood supply at present. It is probable that such blood supply existed at the time of operation, accounting, at least partially, for satisfactory healing. Patient J. I. has remained without symptoms for eight years after a peripheral nerve block due to crushing of the posterior tibial, anterior tibial, superficial peroneal, and sural nerves. Patient J. C. has worn an artificial leg without discomfort for seven years, following a modified guillotine amputation below the right knee. Patient R. S. is a female with healing of a right great toe amputation site, who has since been ambulatory for three years without symptoms. The pathological examination of the arteries in the amputated specimen confirmed the diagnosis of thrombo-angiitis obliterans.

Figure 4, B, gives data for patients with active thrombo-angiitis obliterans. In this

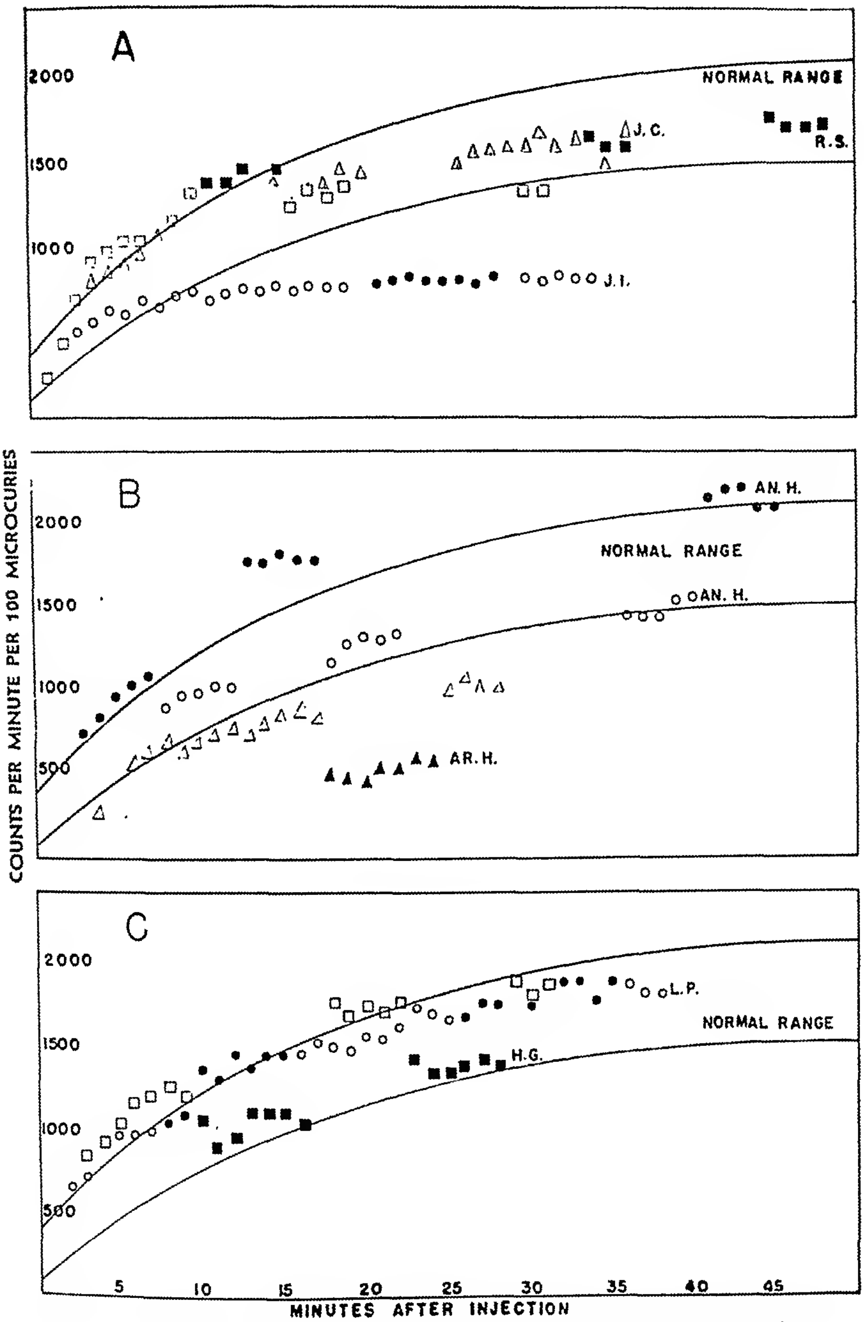

Fig. 4. Radiosodium build-up curves. A and B. Thrombo-angiitis obliterans. C. Chronic varicose ulceration. For details see text.

type of patient, if one foot is more definitely involved in the pathological process than the other, the two usually present different counts; this is well illustrated by the two cases shown. Patient Ar. H. came to amputation below the right knee; the arteries of this extremity showed changes typical of thrombo-angiitis obliterans. Subsequently, in another hospital, he underwent amputation below the left knee. The single slide made available to the Presbyterian Surgical Pathology Laboratory from that hospital showed *changes typical of arteriosclerosis, but no evidence of thrombo-angiitis obliterans.* This is of interest in view of the low sodium curve for the right and approximately normal one for the left foot. Patient An. H. has suffered repeated ulcerations of the right great toe, which shows slight healing with no gangrene.

The high count is associated with local inflammatory changes.

Two cases of chronic varicose ulceration are illustrated in Figure 4, C. Patient L. P. exhibits the condition in both medial lower third crural regions; patient H. G. has an intractable ulceration on the left great and second toe, associated with varices on the dorsum of the foot and in the internal saphenous vein. The dorsalis pedis and posterior tibial arteries in both cases are normally palpable, and their sodium counts lie within the normal range.

Various types of vascular obstruction are demonstrated in Figure 5. In A are data for two patients with thrombosis of the abdominal aorta, both proved by postmortem examination. Sodium tests were done soon after the onset of symptoms, and a few days before death. In patient E. H. very low counts were obtained at both feet. She showed gangrene of both lower extremities. A right lower third of the thigh amputation was done; the site became gangrenous. This patient also had multiple sacral, buttock, and abdominal wall decubiti. Patient C. S. showed no count whatever at his right foot but, on the fifth day following his accident, a fairly adequate count at the left. Amputation sites at the upper third of the right thigh and lower third of the left thigh granulated. The patient had a paralyzed bladder and rectum and an enormous sacral decubitus.

Figure 5, B, demonstrates 3 cases of advanced peripheral arteriosclerosis in young people in whom femoral arteries were not palpable. In patients J. D. and E. W., neither femoral was palpable and both feet showed low counts; patient Y. S. had a palpable right femoral artery and a normal right foot curve. Her left leg has responded very slowly to pressure-suction boot, whirlpool bath, and massage treatments. Patient E. W., with marked cyanosis of both feet, is responding slowly but definitely to the same type of physical therapy. Patient J. D., after five years of clinical observation, succumbed to a coronary thrombosis, one year after a right hemiplegia from a cerebral thrombosis.

Four cases with venous involvement are illustrated in Figure 5, C. Patient M. N. represents an extraordinary case of thrombophlebitic gangrene of both feet, of unknown etiology but associated, as proved postmortem, with a carcinoma arising from the bile radicles of the left lobe of the liver. The extremities were very edematous, which probably accounts for the nearly normal sodium reading after half an hour, since after this interval sodium is contained in any extracellular fluid. Patient A. H. had, clinically, a phlebitis emanating from the right deep calf veins, with venographic evidence of occlusion of the right femoral vein. The right foot was edematous. The curve for the uninvolved left foot is a low normal; the higher values for the right are due to the presence of edema fluid, since this also takes up sodium. Patient F. S. had an extreme femoral-iliac phlebitis with varicose ulcerations of both lower leg regions, associated with scleroderma. The low counts could be due to the latter condition (see Fig. 7, A) but may also indicate diminished circulation from other causes. Patient J. S. had thrombophlebitic gangrene resulting from prolonged ice therapy of the left foot and lower third of the leg because of pain. The indicated count is entirely due to sodium in the rest of the body; none of the material reached the foot. Following amputation just above the gangrenous region, the arteries in the foot were seen to be patent, the veins thrombosed. The operative site healed readily.

In Figure 6, A and B, are shown cases of immersion foot and frostbite. Patients J. M. and J. W. had immersion foot following exposure to water and cold in open boats in the North Atlantic a year prior to the tests. J. W. showed no obvious pathological changes. The dorsalis pedis and posterior tibial arteries were normally palpable, but he complained of severe pain especially on walking and on exposure to cold. His low count was rather surprising and is not readily explained. J. M. had similar findings but his pain was less severe, as might be deduced from his higher curve. I. K.'s left foot was frozen in a bliz-

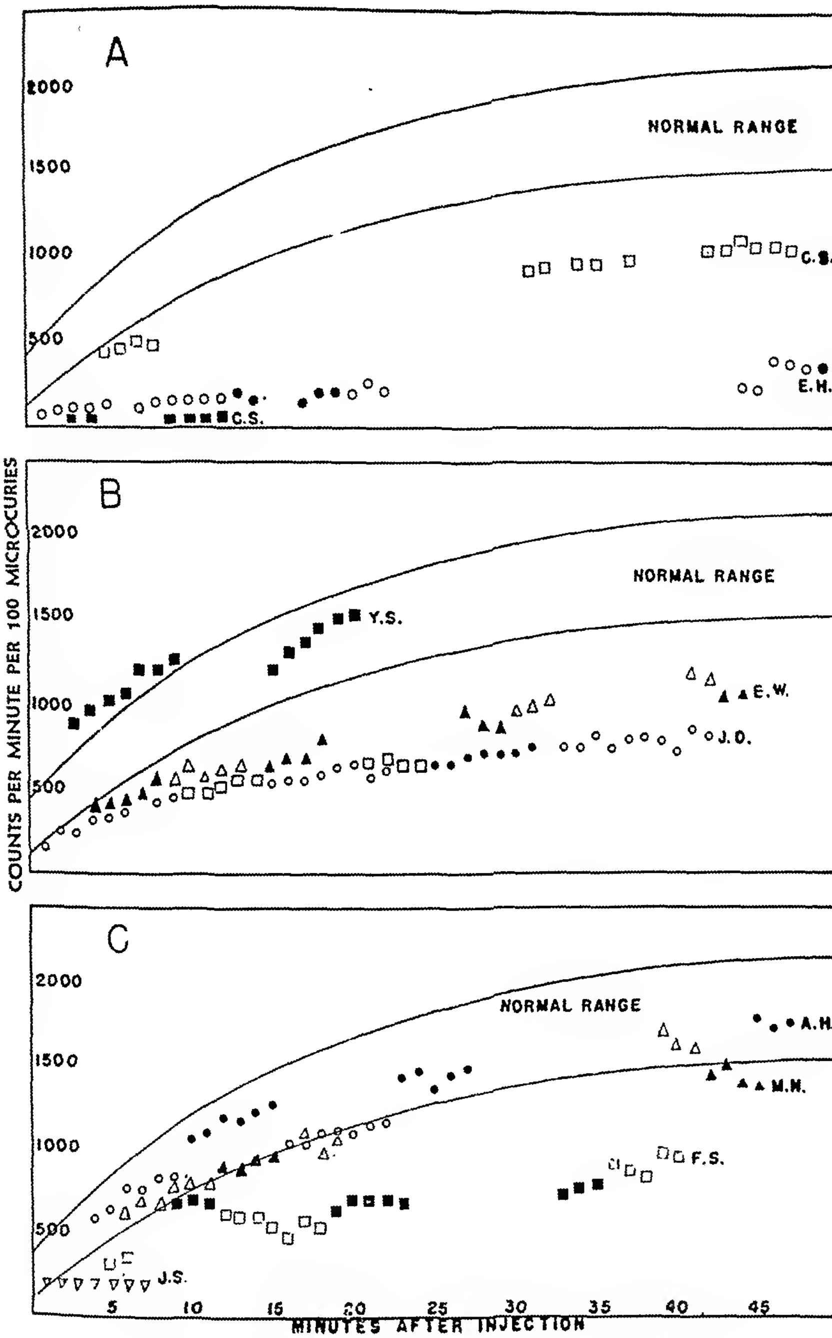

Fig. 5. Radiosodium build-up curves in various types of vascular obstruction. For details see text.

rd nine years ago. Part of the first and cond toes sloughed off; the foot has reained healed. The fact that both feet iow rather low curves suggests slight bilatal involvement. Patient N. S. (Fig. 6, B) ad immersion foot following exposure in ie South Indian Ocean in winter. He has ndergone a left lumbar alcohol block, for ain. The resultant release of vasoconriction is demonstrated by the very high sodium count on that side. The untreated right side still shows the low count associated with immersion foot. In view of the increase in count following lumbar block in this instance, and for other reasons, posterior tibial nerve blocks with perineural novocaine infiltration at the internal malleolus were done in some other cases. Figure 6, C, shows the result in two cases of peripheral arteriosclerosis. The nerve

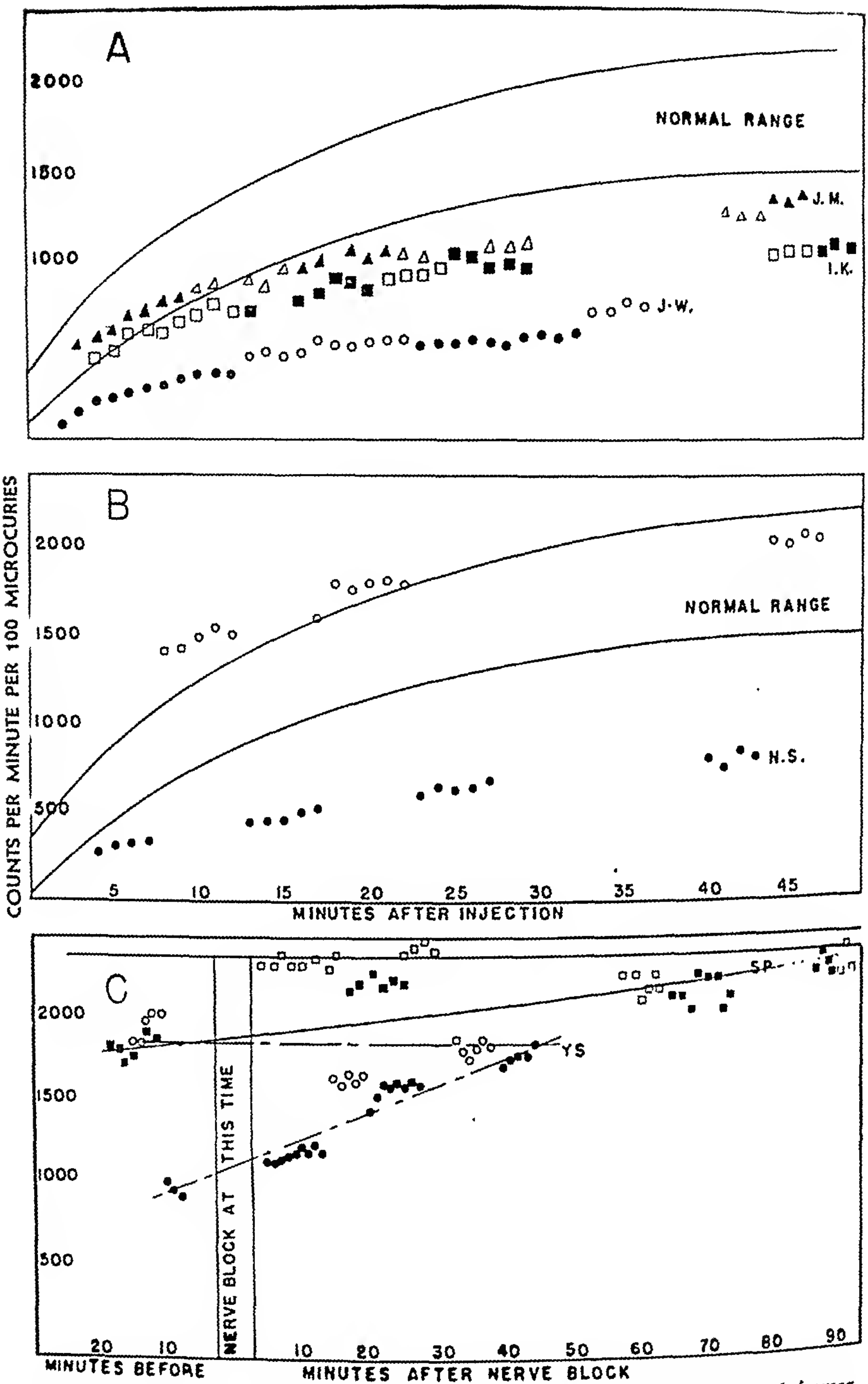

Fig. 6. A and B. Radiosodium build-up curves in frostbite and immersion foot. C. Increase in sodium count after tibial nerve block. For details see text.

blocks were done more than an hour after the sodium injection and when the curves had become stable. Patient S. P. had come to a low normal level, that for the left, more painful, foot being somewhat higher. Y. S. exhibited the same relatively high count in the painful foot; that for the supposedly uninvolved one was quite low. By the end of an hour after injection, sodium equilibrium between intravascular and extravascular fluid is almost reached. For this reason release of arterial spasm could not be expected to produce much increase in count, but might be demonstrable. In both of these cases, the count increased in the non-painful foot, markedly in Y. S., slightly but definitely in S. P., demonstrating that some vascular dilata-

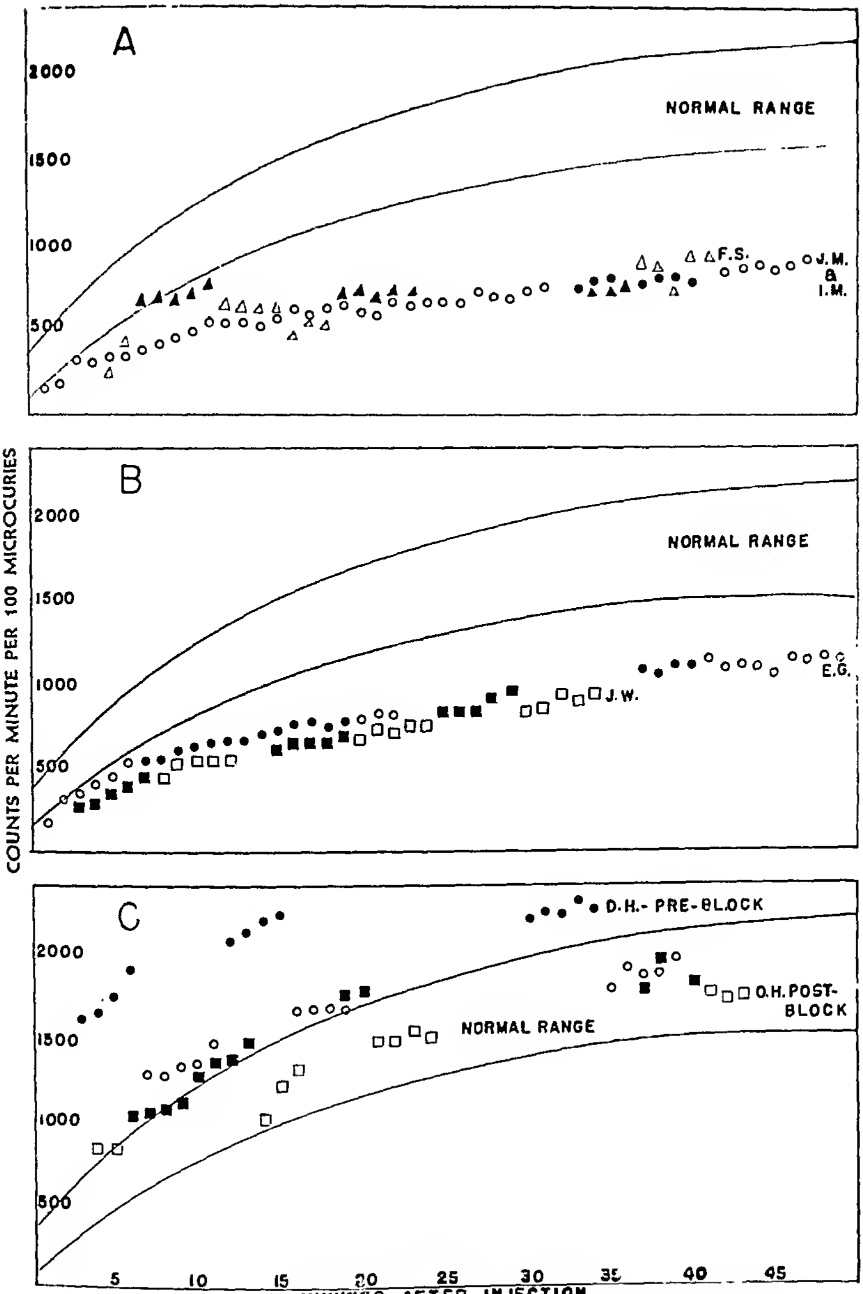

Fig. 7. Radiosodium build-up curves. A. Scleroderma. B. Raynaud's disease. C. Erythromelalgia. For details see text.

...ion did occur. No change was found in the very painful foot; this is a significant clinical finding.

Figure 7, A, shows data for three characteristic cases of scleroderma. These patients always exhibit low curves. In Figure 7, B, are curves for two cases of Raynaud's disease; these are also low. In patient E. G. this low curve was diagnostic. She complained of pain in her hands; her feet were symptomless, and it was thought that they would give counts within the normal range.

In Figure 7, C, is presented an interesting case of erythromelalgia following a slight trauma. In the acute stage of the disease, the count in the affected foot was very high, indicating inflammation or vascular dilatation. Following an alcohol lumbar sympathetic nerve block, the pain

was relieved and the count came to normal.

In addition to studies of the types just discussed at some length, some other investigations may be mentioned. Counts have been done on many persons at various levels of the legs; these are more variable than those at the feet because of the volume of tissue exposed to the counter. However, a basis has been established for recognizing satisfactory blood supply; this has made it possible, in a considerable number of instances, to amputate below the knee, with confidence that healing would occur. Previously many of these patients would have been subjected to amputation above the knee.

In a patient with an arteriovenous fistula in the thigh, diminished blood supply to the foot on that side was demonstrated, with return to normal supply following repair of the fistula.

In a selected group of cases, repeated counts are being made following the use of various drugs or types of physical therapy; these findings will be published later.

SUMMARY

An objective method is presented for the study of blood circulation; this is of particular interest in its applicability to patients having peripheral vascular disease. Its use in more than 200 cases to date has given valuable clinical aid by determining circulation time and demonstrating competency of the arterial circulation. It has been of special value in determining the advisability of persisting i conservative as compared to more radic local surgery, and particularly in dete mining the site of amputation at which hea ing might be expected. In this capacity has justified the clinical attitude that i many cases of amputation for gangrene i peripheral vascular disease the knee joi can be saved.

Since no toxic material is injected wit the sodium, and the accompanying dose radiation is considerably less than or roentgen for each test, there is no contr indication to its repetition at reasonab intervals. In this manner it serves to follo progress of the disease or to test the e ficacy of therapeutic measures.

More cases are continually being studie by this method with the aim both of o taining information about the individu patient and of building up series of simil cases from which it may be possible to dra general conclusions.

NOTE: The authors wish to express their indeb edness to Professor Dunning, Dr. Reid, Dr. Gla ford, and other members of the staff of the cyclotr laboratory of Columbia University, who lent t apparatus and are providing the sodium for the wor Without their co-operation this study could not ha been carried on at this time. They also wish t thank Mrs. Ruth Petro for her technical assistan in carrying out the counts on patients, prepari charts, and keeping records.

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The Roentgen Appearance of Lobar and Segmental Collapse of the Lung

VI. Collapse of the Upper Lobes[1]

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COLLAPSE OF A single lobe of the lung is most frequently misinterpreted hen it occurs in one of the upper lobes. is confused with a localized area of onsolidation, a mediastinal tumor, or an ortic aneurysm, and in some instances, specially in the presence of a long standing fibrotic process without apparent atectasis, it may be completely overlooked. s occurrence is relatively infrequent as ompared with collapse in the lower lobes the middle lobe, but it is common enough warrant greater emphasis than has been ven it in the literature. In the group of 0 cases forming the basis of this study,[2] le upper lobes were involved in 95, or 16 er cent. Certain roentgenologic signs hich characterize collapse of an upper be and which, if recognized, will lessen me of the confusion regarding its diagosis will be described.

It has been noted in earlier papers of is series that in the majority of instances is possible with satisfactory technic to emonstrate the septa which bound the dividual lobes of the lung. These lines, hich roentgenologically can be thought as partitions between the various lobes, re seen to best advantage on the lateral entgenogram. The routine postero-anrior view is depended upon to show any bnormal shadow of increased density, he presence and degree of emphysema in he adjoining lobes, the position of the rachea and upper mediastinum, the relaive planes in which the hili are located, nd usually the minor septum.

The upper lobes lie superiorly and aneriorly in the chest; that is, the left upper lobe is anterior to the major septum along its entire course, while the right upper lobe lies above the minor septum and anterior to that portion of the major septum above its junction with the minor septum. The location of a normal lobe in relation to the septa is stressed repeatedly because of its diagnostic significance. By the recognition of the individual lobes and the septa which bound them, it becomes more nearly possible to demonstrate on a roentgenogram the precise unit of a lung that is projected on a given area. In this way, it is possible roentgenologically to recognize the presence of a pulmonary unit which is not assuming its full share in aeration even before an abnormal shadow of increased density, indicating the nature of the disease process (or in some instances its result) can be detected. The significance of this concept is similar to that of a break in the peristaltic wave in the stomach pointing to a neoplasm or ulcer crater which otherwise might be overlooked.

With a few exceptions, the roentgen appearance of collapse of an upper lobe or of its segments is essentially the same regardless of the side involved. On the left, the lingula of the upper lobe occupies a position in the chest similar to that of the middle lobe on the right, but it derives its bronchial supply from the left upper lobe bronchus and is not separated from the remainder of the upper lobe by a fissure. The similarity in the appearance of a right middle lobe and a lingula on the left has been previously mentioned. The lingula is often collapsed when the remainder of the left upper lobe is involved, but in

[1] From the Department of Radiology, Massachusetts General Hospital, Boston 14, Mass. One of a series of apers accepted for publication in October, 1944.
[2] See Radiology 44: 471, 543, May and June 1945; 45: 23, 120, 260, July, August, September 1945.

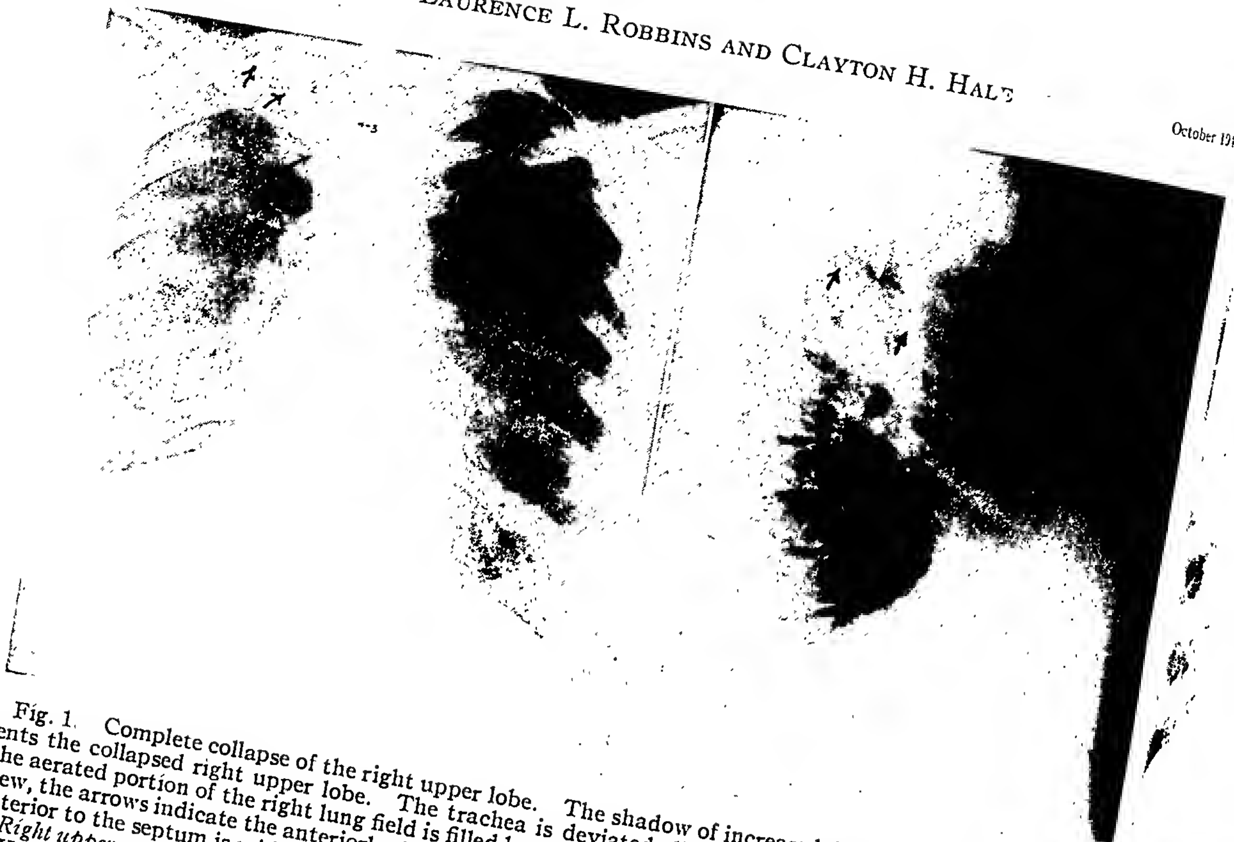

Fig. 1. Complete collapse of the right upper lobe. The shadow of increased density, outlined by arrows, repr[e]sents the collapsed right upper lobe. The trachea is deviated slightly to the right; the right hilus is elevated. The aerated portion of the right lung field is filled by emphysematous right lower and middle lobes. In the lateral view, the arrows indicate the anteriorly displaced major septum of the right lung. The aerated portion of the lung anterior to the septum is middle lobe. The asterisk overlies the collapsed right upper lobe.
Right upper and middle lobectomy. The right upper lobe was markedly decreased in size.
Histopathology: Tuberculosis.

none of the cases studied was collapse of a middle lobe associated with a similar process in the right upper lobe, unless the entire lung was collapsed. In a discussion of the upper lobes, therefore, the presence of the lingula on the left is significant only when it and the remainder of the left upper lobe are simultaneously collapsed. When this occurs, the entire shadow of increased density is slightly larger than that of collapse of the right upper lobe and it extends farther inferiorly along the anterior chest wall.

Demonstration on the lateral roentgenogram that a major septum is no longer in its normal position may be the first evidence suggestive of decrease in the size of an upper lobe. The septum will appear to lie farther anteriorly, and its superior portion will extend higher in the chest. At about the time the lobe has diminished to approximately two-thirds of its normal size, it may be noted that the supposedly normal pulmonary markings appear to be somewhat more closely grouped than is usually seen. As the collapse increase[s] the lung markings seem to be actuall[y] crowded together, and the lobe is seen to occupy a constantly diminishing space. At this point the increased number of markings per unit area will usually make the now small lobe cast a definite shadow of increased density in contrast with the adjacent uninvolved lung. The latter will now be emphysematous, since it necessarily has had to increase in size to fill the space formerly occupied by the collapsed lobe which, as it became smaller, continued to move further anteriorly and medially.

Collapse of an upper lobe produces a shadow of increased density rather typical in shape and position in the chest. It is somewhat fan-shaped or triangular, with a fairly broad base as it first becomes visible. As the process progresses, however, the base, or peripheral border, becomes shorter, the appearance being comparable to the gradual closing of a once fully opened fan. The apex of the shadow appears to arise from the top of the hilus and its base

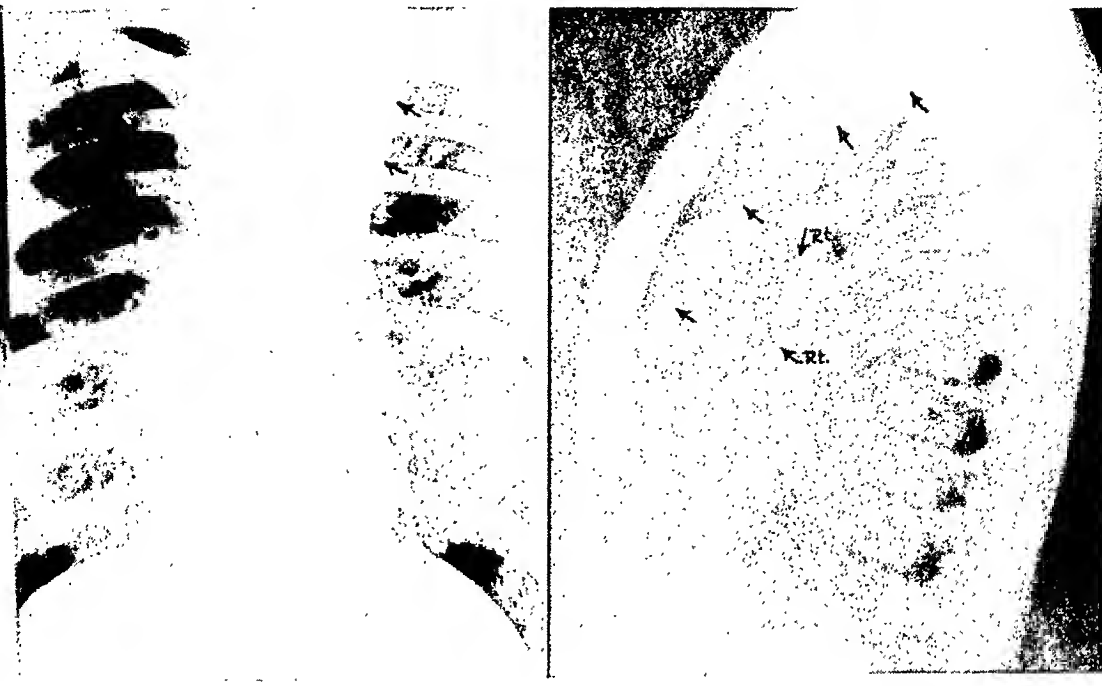

Fig. 2. Complete collapse of the left upper lobe. The lateral margin of the shadow of increased density is dicated by arrows. The left hilus is elevated. The aerated lung in the left chest is left lower lobe. In the teral view, the posterior margin of the shadow of increased density is shown anteriorly in the left chest (arrows) id represents the posterior margin of the collapsed left upper lobe. The positions of the right major and minor pta are indicated. This is the typical appearance of collapse of an entire upper lobe.
Left upper lobectomy. The upper lobe was found to be completely collapsed.
Histopathology: Bronchiectasis.

tends against the top and anteromedial ırface of the chest wall. Since the collapsed lobe lies in the gentle concavity of ıe medial and anterior portion of the leural space, the shadow of increased ensity appears to be much the same shape ı both postero-anterior and lateral roentenograms. The position finally assumed y the shadow of density differs from that een in collapse of a lower lobe, which lways lies posteriorly rather than anteriorly if there has been no previous trauma the pleura.

A collapsed upper lobe may in some cases ecome so small and move so far anteriorly and medially that in the posteronterior projection the shadow of increased ensity will blend with that of the upper ıediastinum and the combined shadow vill merely suggest mediastinal widening. In the lateral view, the shadow may become assimilated with that of the upper nterior chest wall and be readily overooked. The area between the ascending nd transverse portions of the aorta and the chest wall, which is normally of increased radiability, now becomes obliterated and approaches the density of the soft tissues. Nevertheless, the presence of a shadow of increased density can still be determined in this view if the surfaces of the ascending and transverse portions of the aorta are observed carefully to determine whether or not they are as distinctly outlined as usual. If the border of the aorta is partially or completely obscured, it can be assumed that it is adjacent to nonaerated lung; in other words, that the upper lobe is atelectatic. The appearance of the anterior surface of the ascending aorta is of importance particularly in relation to the right upper lobe, since the left contributes little to its visualization. In collapse of a left upper lobe, the transverse portion of the arch of the aorta may not be as clearly defined as usual, for like reason, since that portion of the aorta is more or less in contact with the lobe. It should be mentioned, also, that a collapsed entire left upper lobe seldom becomes as small

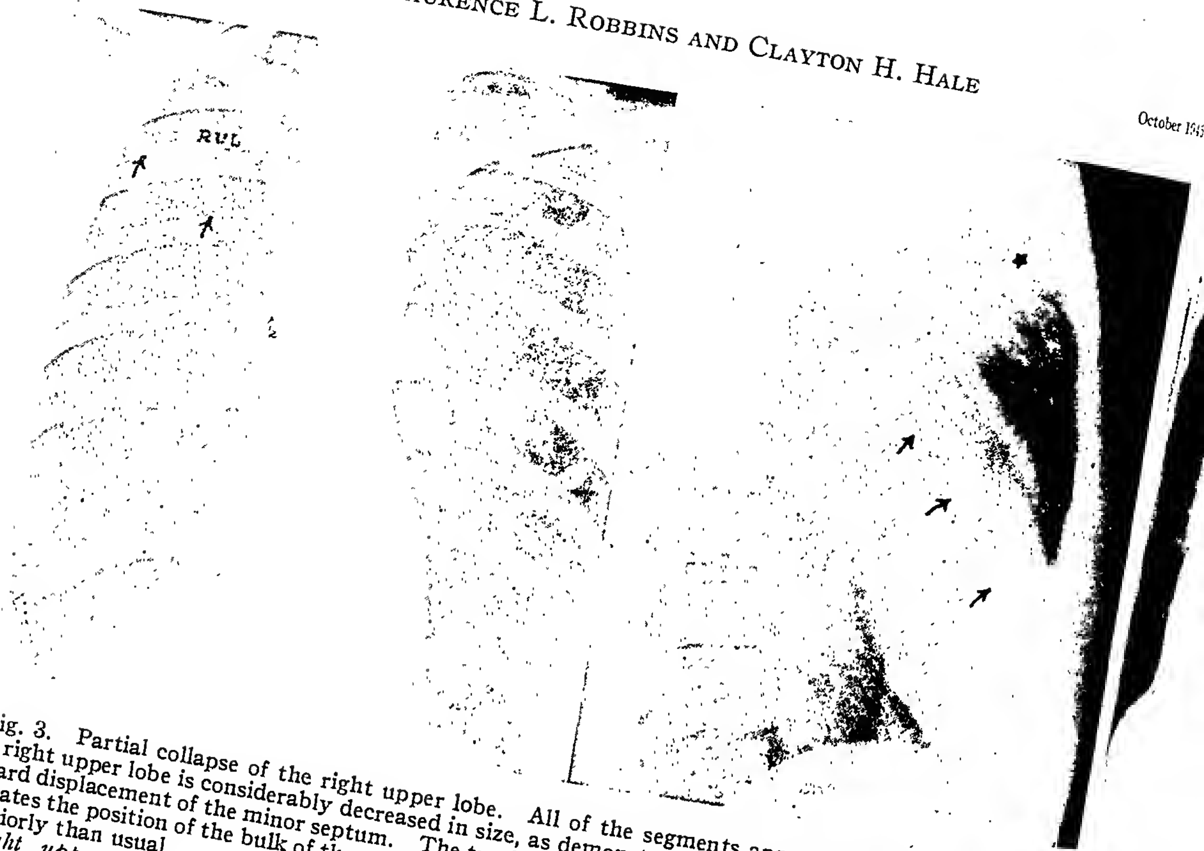

Fig. 3. Partial collapse of the right upper lobe. All of the segments appear to be nearly equally involved. The right upper lobe is considerably decreased in size, as demonstrated by the elevation of the right hilus and the upward displacement of the minor septum. The trachea is deviated to the right. In the lateral view, the asterisk indicates the position of the bulk of the collapsed right upper lobe. The right major septum lies somewhat farther anteriorly than usual.

Right upper lobectomy.

Histopathology: The right upper lobe was small, showing tuberculosis with cavitation and fibrosis as well as numerous tubercles.

as a collapsed right upper lobe because of the greater amount of lung tissue involved. In addition, the lingular portion will generally extend far enough down the anterior chest wall so that it can be recognized as an abnormal area of increased density, although in extreme collapse the lingular shadow may be difficult to identify, as it is very small and merges with the mediastinum.

As in collapse of a lower lobe, an upper lobe can be decreased in size without a great amount of atelectasis being visible. When this occurs, the roentgenogram is frequently interpreted as showing a minimal tuberculous lesion because the area of atelectasis is small and the decrease in the size of the lobe is not appreciated. Also, if the collapse is due to a chronic condition in which secondary fibrosis occurs, as in tuberculosis or bronchiectasis, the process may remain stationary for many years. If the cause of collapse of an upper lobe is an acute obstruction, the process will develop much more rapidly and will also clear more rapidly than with chronic obstruction.

As an upper lobe decreases in size, the hilus tends to move into a higher plane and its superior portion may be merged in the shadow of increased density. This blending of the two shadows often creates the impression that the hilus is elevat[illegible] farther than is actually the case and pro[illegible]ably explains why at times it appears t[illegible] become smaller. In general, the eleva[illegible]tion of the hilus depends upon the degree of collapse. As a rule, the elevation [illegible] collapse of an upper lobe was more striking than was the depression of the hilus associated with collapse of a lower lobe. If the collapse is of short duration, the change in the position of the hilus may be readily observed, for it will return to its normal position with re-expansion of the lobe. The presence of a tumor occasionally seems to interfere with the elevation of the hilus in collapse of an upper lobe.

Fig. 4. Collapse of the left upper lobe excluding the lingula. The shadow of increased density is outlined by rows. The diaphragm is elevated, and fluoroscopically showed paradoxical motion. The left heart border is arly outlined. In the lateral view, the posterior margin of the shadow of density represents the major septum ich has been displaced anteriorly and superiorly. The lingula is seen to be fairly well aerated. *Exploratory thoracotomy.* The upper lobe was found to be extensively involved in a carcinomatous mass which is inoperable because of mediastinal extension. *Histopathology:* Epidermoid carcinoma, grade III.

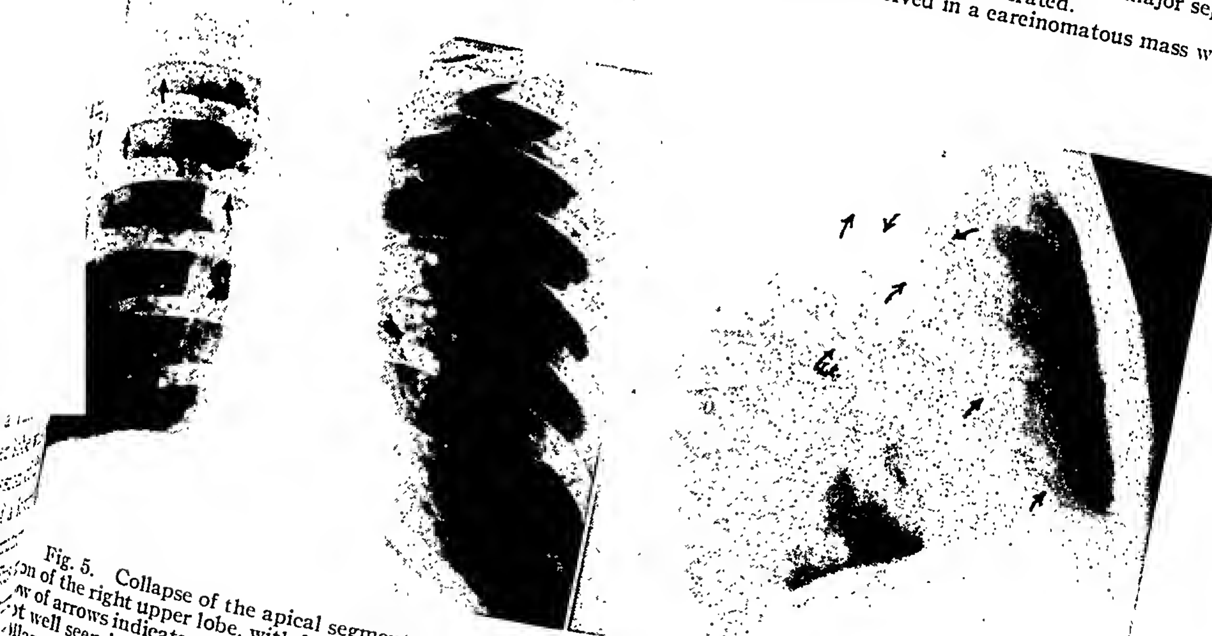

Fig. 5. Collapse of the apical segment of the right upper lobe. There is increased density in the apical poron of the right upper lobe, with fairly good aeration of the lower portion. In the postero-anterior view, the lower w of arrows indicates the position of the minor septum; the upper row, the position of the major septum (usually ot well seen in this projection). The right hilus is elevated and the trachea is displaced somewhat toward the llapsed side. In the lateral view, the right major and minor septa are indicated by arrows. The left major ptum is visualized and in normal position. *Right upper lobectomy.* The apical segment of the right upper lobe was found to be atelectatic. *Histopathology:* Chronic pneumonitis and slight bronchiectasis.

Fig. 6. Collapse of the posterosuperior segment of the left upper lobe. The shadow of increased density is seen to lie farther laterally than that usually seen in collapse of an apical segment. In the lateral view, the area of density lies against the major septum, which has not been appreciably displaced.
Left upper lobectomy. Segmental collapse was demonstrated at operation.
Histopathology: Tuberculosis.

The upper mediastinum, and especially the trachea, often show slight to moderate displacement toward the collapsed side. Tracheal displacement, even though it is slight, when seen in association with the other signs mentioned above, may be a valuable adjunct in the diagnosis of collapse of an upper lobe. The mediastinal displacement is seldom as marked as in collapse of a lower lobe and, as a rule, the lower part of the mediastinum and the heart maintain their normal position. The appearance of the intercostal spaces usually shows little or no change from normal.

The diaphragm may show slight, but seldom marked, elevation and limitation of motion in collapse of an upper lobe. It should be mentioned, however, that a neoplasm in an upper lobe frequently produces phrenic nerve paralysis as an early manifestation, in which case the diaphragm will show true paradoxical motion.

Any change in the position or contour of the septa may be of diagnostic importance in collapse of an upper lobe as it is in collapse of other lobes. When the entire upper lobe is collapsed, the major septum, while often retaining its normal contour, is displaced anteriorly. It may lie nearly against the anterior chest wall so that its uppermost portion must rise to the region usually occupied by the apex of the lung. In collapse of a right upper lobe, the minor septum may extend to the extreme top of the chest, and its shadow be assimilated with that of the apical pleura. If this occurs, the major septum will extend to the extreme apex of the right pleural cavity, and all of the aerated lung anterior to it will be right middle lobe, which will have expanded to occupy a large part of the area previously filled by the upper lobe.

As has been noted, collapse of an upper lobe can be confused with lesions of the mediastinum and aorta. This is largely due to the appearance of the shadow of increased density. If the other signs of collapse of an upper lobe, which have been described, are borne in mind, a mistaken diagnosis will be less likely.

SEGMENTAL COLLAPSE OF AN UPPER LOBE

The appearance of collapse in the lingula of the left upper lobe has been described

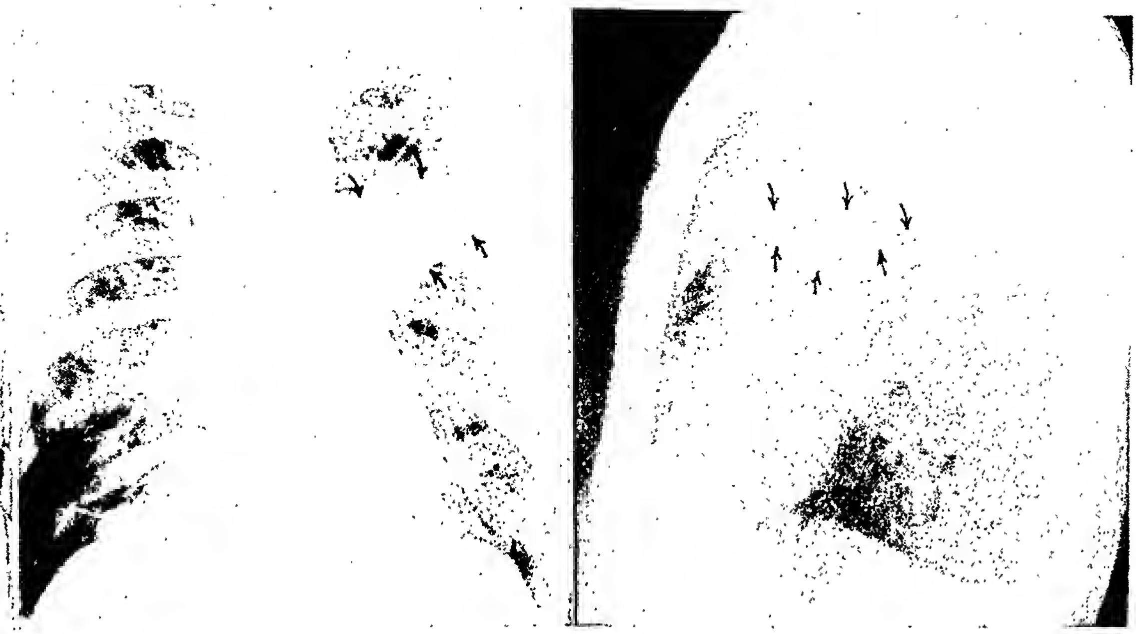

Fig. 7. Segmental collapse of the left upper lobe involving the antero-inferior, lateral, and lingular segments. The shadow of increased density, outlined by arrows, overlies the left hilus. There is no appreciable displacement of the trachea or mediastinum. The lateral view shows the shadow of density as well as the marked upward displacement of the inferior portion of the major septum (lower anterior two arrows).
Left pneumonectomy.
Histopathology: Epidermoid carcinoma, grade II.

elsewhere. For practical purposes the remaining segments are common to both the right and left upper lobes. They are usually recognized as the apical portion, the antero-inferior portion, the postero-superior portion, and the lateral or axillary portion. Each of these divi ions is supplied by a branch from the upper lobe bronchus except the axillary segment, which is usually supplied by two somewhat smaller bronchi—in the majority of cases subdivisions of the bronchi to the postero-superior and antero-inferior segments. In some cases, however, either the anterior branch or the posterior branch to the axillary portion of an upper lobe may be represented as a major subdivision arising directly from the upper lobe bronchus. It should be noted that on the left side the bronchus to the posterosuperior segment in many cases arises from the bronchus to the apical segment rather than directly from the upper lobe bronchus. Several other minor variations in the distribution of the bronchi to the upper lobes may occur, but further discussion is beyond the scope of this paper.

A collapsed apical segment (the segment most frequently involved in partial collapse of an upper lobe if the lingula is excluded) stands out as an area of increased density anteriorly and against the mediastinum. The adjacent segments of the upper lobe are aerated, allowing visualization of the major septa and, on the right, of the minor septum. This differs from collapse of an entire upper lobe, in which the septa are blended with the shadow of increased density.

In collapse of the posterosuperior portion of an upper lobe, the shadow of density is seen to lie posteriorly and against the major septum, which forms its posterior margin, and somewhat laterally and superiorly. It is apparent, however, that the apical segment above is aerated.

The antero-inferior segment, when collapsed, casts a shadow which on the right is bounded inferiorly by the minor septum and extends anteriorly from approximately the mid chest to the anterior chest wall. The septum tends to be slightly elevated. On the left, the location of the shadow is similar, but there is no sharply defined in-

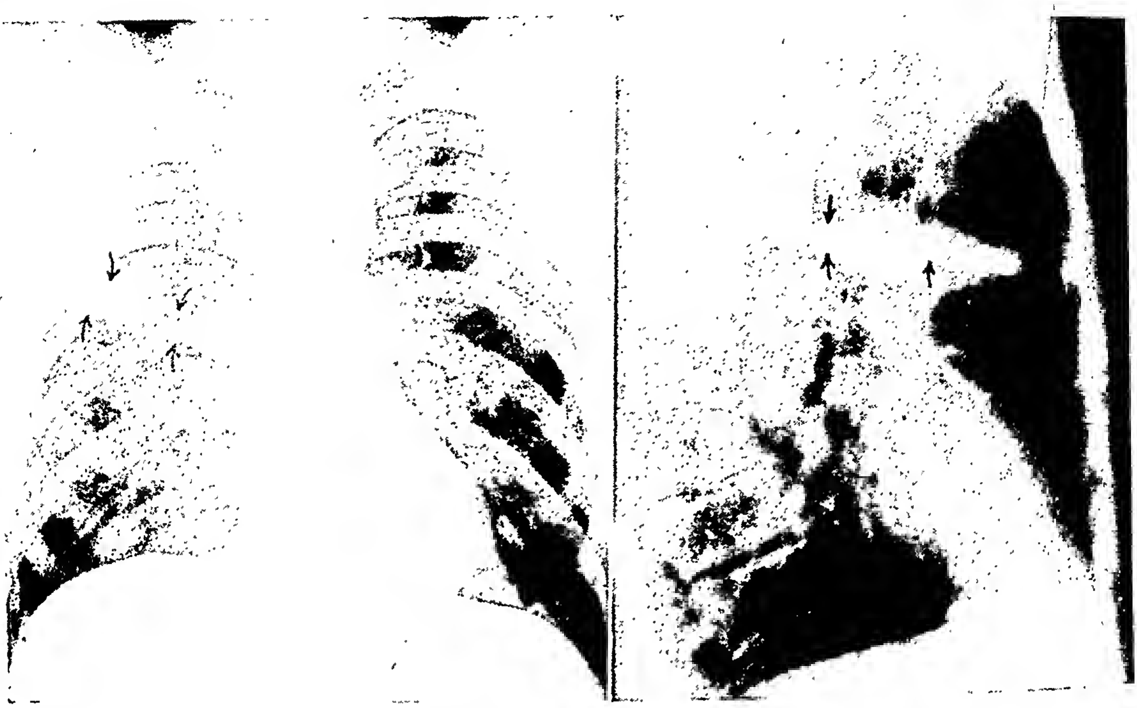

Fig. 8. Segmental collapse of the right upper lobe involving the antero-inferior and axillary segments. The band-like shadow of increased density extends laterally from the right hilus. Neither the hilus nor the minor septum is appreciably elevated. In the lateral view, the shadow of density is clearly demonstrated. The sharply defined inferior margin represents the location of the minor septum.

Right upper lobectomy.

Histopathology: Benign adenoma. The parenchyma of the antero-inferior and lateral segments of the lobe was collapsed.

ferior margin, due to the absence of a minor septum. Aerated upper lobe is seen to lie above the shadow, whether the collapsed segment is on the right or the left side.

Collapse of the axillary portion of an upper lobe is usually associated with collapse of either the antero-inferior or the posterosuperior portion, or both. If the axillary segment alone is involved, the shadow, as seen in the postero-anterior view, is somewhat triangular and is located laterally against the chest wall with a sharp inferior margin on the right due to the minor septum, the lateral portion of which is somewhat elevated. The posterior margin of the shadow is also sharply defined, as the major septum forms the posterior boundary. The findings on the left side are similar except that, as in collapse of other segments, the minor septum is absent. If the axillary segment is collapsed in combination with other segments, the resultant shadow will appear as a fusion of the shadows already described.

In general, segmental collapse of an upper lobe produces variable degrees of elevation of the hilus, but this is not as marked as in complete upper lobe collapse. The degree of elevation depends upon the segment in which collapse occurs, being greatest when the apical and least when the antero-inferior segment is involved.

The major septum shifts anteriorly from its normal position, the extent of the shift being dependent upon the degree of collapse and the segment involved. It has seemed that those segments lying more anteriorly cause a greater shift than those lying posteriorly, but this appearance may be due to difference in the bulk of tissue involved. In some instances there may be no apparent anterior displacement of the septum as a whole, but its accentuated anterior convexity will suggest a decrease in the size of the adjoining segment.

Displacement of the trachea and other superior mediastinal contents is usually not as marked in segmental as in complete collapse of an upper lobe. Although displacement may be considerable when an

apical segment is collapsed, it is much less when the collapse is confined to one or more f the other segments. Segmental colıpse produces little if any change in the osition or motion of the diaphragm and, ecause only a small unit of lung is inolved, the emphysema in adjacent pulıonary tissue is usually not striking.

CONCLUSIONS

Collapse of an upper lobe is frequently ot recognized because its roentgenologic ppearance is not well known and the riteria by which collapse has formerly ıeen characterized are less applicable to n upper lobe than to a lower lobe or the ntire lung.

Collapse of an upper lobe produces a rather characteristic shadow of increased density lying anteromedially. When this shadow is associated with other signs indicating a decrease in the size of the lobe, such as anterior displacement of the major septum and elevation of the hilus, collapse should not be confused with other lesions in the chest.

NOTE: The close co-operation between the Departments of Surgery, Pathology, and Radiology made this study possible, and particular acknowledgment is due Dr. Richard H. Sweet and Dr. Ronald C. Sniffen.

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Pantopaque Myelography: Correlation of Roentgenologic and Neurologic Findings[1]

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CONTRAST myelography has been practised for the past twenty-five years with various media and technics. Dandy (5) was the first to employ air for the purpose, and Coggeshall and von Storch (4) and Chamberlain and Young (3) were among the early and most enthusiastic advocates of air as a medium. Chamberlain and Young found that "in each case in which operation was performed, the exact level of the lesion determined by myelographic examination was verified by laminectomy." Camp (1) also reported on the use of air. He stated that the positive findings were 90 per cent accurate, but 74 per cent of those operated upon after a negative myelographic examination proved actually to have lesions of the spinal canal. Hampton and Robinson (8) and Camp and Addington (2) are among the advocates of lipiodol for myelography, Hampton (7) claiming 93 per cent accuracy for that medium. Thorotrast has been employed by Nosik and Mortensen (10, 11). In a recent communication, Dandy (6) recommended establishing a diagnosis on the clinical and roentgenologic findings, without contrast material. The advantages and disadvantages of the various procedures have been well summarized by Pugh (12).

The earliest use of pantopaque[2] for myelography is credited to Garvey and Jones (15) of Strong Memorial Hospital, Rochester, N. Y., in 1940 and 1941, after extensive animal experimentation. The results of these early clinical trials were summarized by Warren before the Harvey Cushing Society in May 1942. Pantopaque for myelographic purposes was made available to the Armed Services in 1942 and has been used since then by the neurosurgical service of the National Naval Medical Center, Bethesda, Md.

TABLE I: TRAUMA CONSIDERED BY THE PATIENT TO HAVE CAUSED SYMPTOMS

	Patients	Protruded Disks
Lifting heavy objects	15	15
Falls from ladders, down hatch, or on wet decks	15	9
Calisthenics, running obstacle course, drilling, etc.	9	9
Slipping on wet deck or in shower, but without fall	5	4
Carrying heavy objects or patients	5	3
Driving cars or trucks over rough roads	4	2
Athletics	13	11
Playing football (3 patients, 2 disks)		
Playing basketball (1 patient, 0 disks)		
Playing soccer (1 patient, 1 disk)		
Playing golf (1 patient, 1 disk)		
Swimming and diving (3 patients, 3 disks)		
Wrestling (3 patients, 3 disks)		
Bowling (1 patient, 1 disk)		
Landing from parachute jump	1	1
Cranking airplane motor	1	1
Other injuries	4	4
No definite trauma recalled	28	20
	100	79

We were eager to employ this new contrast medium but agreed that it should be used only as an adjunct in the diagnosis and localization of lesions and that a negative myelographic report would not deter exploration if this were warranted on the basis of the clinical examination.

For the purpose of this study we have analyzed 100 consecutive cases on the neurosurgical service with a provisional clinical diagnosis of protruded intervertebral disk. Pantopaque myelography was performed on nearly all patients with low back and sciatic pain in which this condi-

[1] From the Department of Radiology (Captain C. F. Behrens (MC) U.S.N., Chief of Service) and the Department of Neurosurgery (Captain W. McK. Craig (MC) U.S.N.R., Chief of Service), National Naval Medical Center, Bethesda, Md. Presented at the Joint Meeting of the American Roentgen Ray Society and the Radiological Society of North America, Chicago, Ill., Sept. 24–29, 1944.

[2] Pantopaque is a mixture of ethyl esters of isomeric iodophenylundecylic acids.

TABLE II: ROUTINE ROENTGEN FINDINGS IN 100 PATIENTS

	Right	Left	Mid-line			Patients
. Anomalies (spina bifida, lumbarization, asymmetrical development of 5th lumbar vertebra, etc.)						18
A. Explored, disk removed					13	
B. Explored, no disk found					3	
C. Not explored					2	
. Narrowing of intervertebral cartilage space						12
A. Narrow L4-L5 space, disk removed					7	
B. Narrow L5-S1 space, disk removed					4	
C. Narrow L2-L3 space, not explored					1	
. List of lumbar vertebrae						47
A. List associated with disk					38	
List to right				20		
Location of disk—	Right	Left	Mid-line			
a. L4-L5	2	10	3			
b. L5-S1	2	3	0			
List to left				18		
Location of disk—	Right	Left	Mid-line			
a. L4-L5	4	2	0			
b. L5-S1	7	5	0			
B. List not associated with disk					9	
. Loss of lumbar lordotic curve						27
A. Associated with disk					22	
B. Not associated with disk					5	
. Reaction of vertebral bodies adjacent to cartilage spaces (sclerosis, hypertrophic fringe formation, etc.)						10
A. Associated with disk					6	
B. Not associated with disk					4	

on was suspected. It is considered by me neurosurgeons that a protruded disk oduces signs and symptoms so diagnostic at myelography is unnecessary. The nger of this assumption is apparent since mors of the cauda equina are not unmmon and, when small, may produce gns and symptoms indistinguishable from ose due to disk protrusion.

It is not within the scope of the present port to discuss in detail the clinical sympms or the objective neurologic findings the protruded intervertebral disk. The fect of trauma as an etiologic factor and e duration of symptoms are of interest, owever, because we are dealing with aval personnel. In 50 per cent of our ses six months or less had elapsed from nset of symptoms to hospital admission; 0 per cent of the patients had had sympoms for one year or less. The type of auma considered by the patient to have d to the onset of symptoms is of interest nce, with few exceptions, the activities eculiar to naval service were not responsole (Table I).

ROUTINE ROENTGEN STUDY

A preliminary roentgenologic study of he lumbosacral area was carried out in all cases. Each set of films was reviewed for evidence of abnormalities as recorded in Table II, and these findings have been correlated with the surgical observations. The most common abnormalities noted were a list of the lumbar vertebrae to the right or left, present in 47 instances, and a loss of the normal lumbar lordotic curve, in 27 instances. A protruded disk is not precluded by absence of a list, but its presence does make the diagnosis somewhat more likely. List of the spine away from the protruded disk was only slightly more common than toward the side of the protrusion. Protruded disks were found in 22 of the 27 patients showing straightening of the lumbar spine. Those patients having tumors showed no decrease of the lumbar curve except in one instance in which both a tumor and a protruded disk were present. here were only 12 instances of narrowing of the intervertebral cartilage space, and 11 of these were found to be associated with disk protrusion, while the other patient was not explored. Bony proliferation and narrowing of the intervertebral cartilage spaces were present, almost without exception, in patients who had had symptoms for over three years. These findings were observed in older persons,

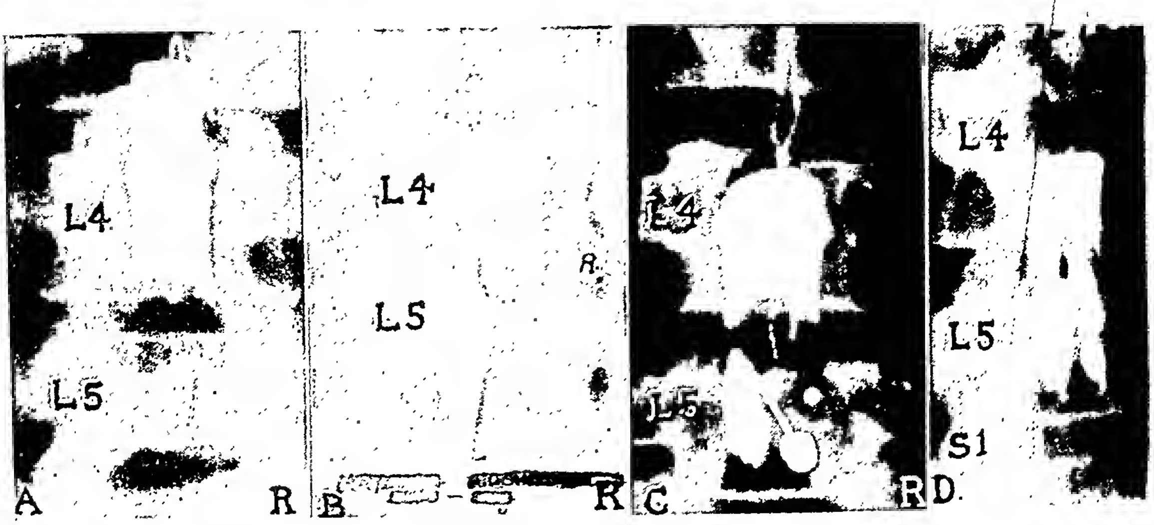

Fig. 1. Mid-line protruded disks.

A. Complete obstruction due to large mid-line protrusion at L4-L5.

B. Same case as A. Following cough the pantopaque has passed the obstruction, demonstrating the excellent fluidity of this medium. A large protruded disk with its bulk extending toward the right was removed.

C. Large mid-line defect due to protruded disk at L4-L5. History of disk removal elsewhere two years previously at L5-S1.

D. Same case as C. Coughing has produced filling, demonstrating a division of the opaque column at the site of the mid-line protrusion. It was impossible to fill the space at L5-S1. A large mid-line protruded disk was found at L4-L5 and adhesions were noted about L5-S1 at the site of the previous transdural operation.

but most of those constituting this series were between twenty and thirty years of age. The common anomalies of the lumbosacral area, as spina bifida occulta, lumbarization, and sacralization, were noted in 17 instances, and the presence of such defects has no bearing on the incidence of protruded disks.

The most common roentgen findings associated with a protruded disk are narrowing of the intervertebral cartilage spaces and straightening of the lumbar spine, but these occur in relatively few patients. Spondylolisthesis was detected only once, and in that instance it was associated with a protruded disk.

TECHNIC OF PANTOPAQUE INJECTION

For the performance of lumbar myelography, the patient is placed prone on a tilting fluoroscopic table with a folded pillow beneath the lower abdomen. Another pillow is placed beneath the feet and ankles. This position favors accurate mid-line insertion of the spinal needle. Very obese or poorly relaxed patients are placed in the usual lateral position for lumbar puncture and then gently rolled into the prone position.

The skin is painted with an antiseptic solution and the area of injection is draped with sterile towels. Procaine, 2 per cent, is used to infiltrate the skin, subcutaneous tissue, and interspinous ligament. A short, beveled, 18-gauge lumbar puncture needle is inserted either at the fourth and fifth lumbar or the fifth lumbar and first sacral interspace. We attempt to avoid inserting the needle at the clinical level of the protruded disk. For example, in patients exhibiting the signs of first sacral root compression, the lumbar puncture should be performed at the fourth and fifth lumbar interspace. Before passing the needle point into the subarachnoid space, it is advantageous to elevate the head of the table from 20 to 30 degrees above the horizontal. When a free flow of cerebrospinal fluid has been obtained, 3 c.c. of pantopaque are slowly injected. Care should be taken to avoid admixture of air and oil during the withdrawal of the pantopaque from the ampule and during the injection. Failure to observe this precaution may lead to globule formation, which will render the subsequent study and removal more difficult. Following the injection, the stylet is replaced in the needle

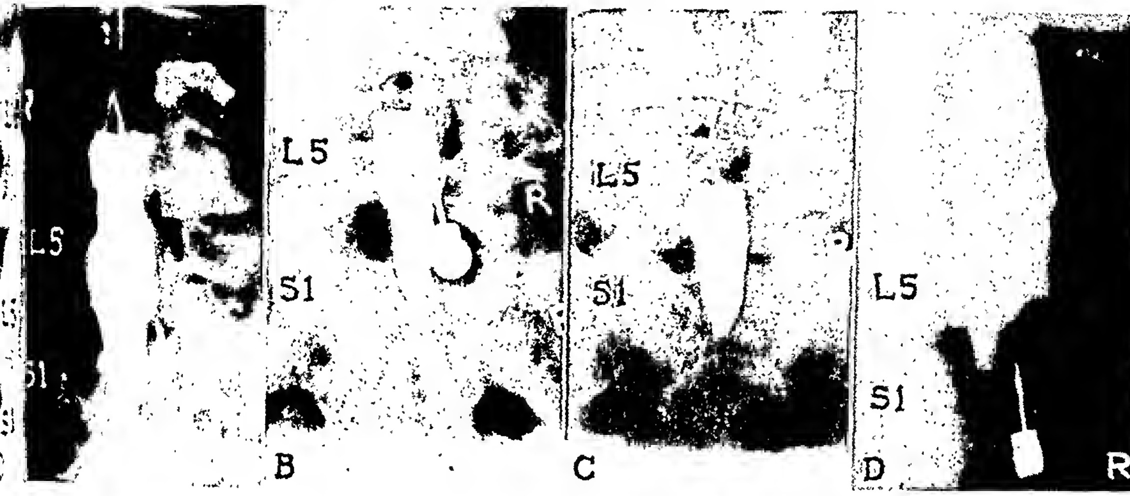

Fig. 2. Protruded disks at the lumbosacral junction.

A. Myelogram positive for protruded disk on the right at L5-S1. Fluoroscopically this part of the column re-ained rigid during coughing while the rest of the column showed distensibility. Confirmed at operation.
B. Myelogram positive for protruded disk at L5-S1 on the left. Note the wide space between the column and pedicle with slight indentation of the column and displacement of the column to the right. A broad, flat, soft d degenerated disk had elevated and displaced the fifth lumbar root.
C. Myelogram positive for a protruded disk at L5-S1 on the left. This deformity was slight but constant. arge protruded disk was found.
D. Myelogram positive for large protruded mass at L5-S1 on the right. The needle was inserted at the level the disk. The pantopaque could not be aspirated. A large protruded disk was found lateral to and beneath first sacral root, displacing it mesially.

d the operative field is covered with a rile towel. The patient is then ready fluoroscopy.

FLUOROSCOPY AND RADIOGRAPHY

The fluoroscopic study is performed only ter adequate dark adaptation. Since e injection was done with the head of the ble elevated 20 to 30 degrees from the rizontal, the pantopaque will be pooled the region of the third to fifth lumbar rtebrae. The table is elevated slowly so at the column is moved to the level of the erspace between the fourth and fifth mbar vertebrae, if not already there, and spot film is exposed. The table is then vated to bring the opaque material to e space between the fifth lumbar and first cral vertebra, and a second film is ex-sed. These films are exposed early in e course of the examination with as little itation of the opaque material as possible, prevent globule formation. The table elevated until the patient is erect and he asked to cough in order that the tip of e subarachnoid sac may be observed and at any resistance offered to the lateral thrust of the column incident to coughing may be noted. The table is then lowered and the fifth lumbar and first sacral and the fourth and fifth lumbar interspaces are studied in greater detail, for any deformity of the subarachnoid space or asymmetry of the axillary sleeves or pouches. Defects should be constant and should be demonstrable whether the opaque column is caused to flow cephalad or caudad.

If there is any suggestion of a defect, it is observed more fully by turning the patient into both 30-degree oblique positions. The lateral position was used in our early cases but was soon discarded because it furnished no additional information. The opaque material is caused to flow as far cephalad as the tenth dorsal vertebra in searching for tumors in the region of the lower end of the cord or cauda equina. This procedure has been performed as a rigid routine, and its value is attested by the finding of five tumors below the level of the tenth dorsal vertebra and, in one instance, a protruded disk and a tumor in the same patient.

The speed of tilt of the fluoroscopic table

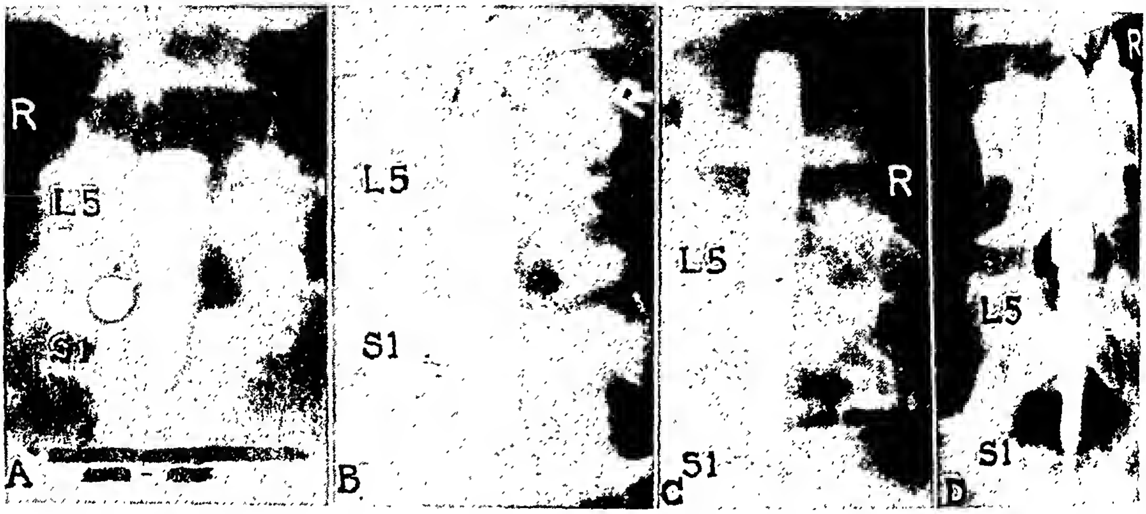

Fig. 3. Myelograms considered negative but disks were found at operation.

A. One large and two small pieces of protruded fibrocartilage were found at L5-S1 on the left. The root was displaced mesially and covered with a membrane.

B. A disk had protruded through a posterolateral defect at L5-S1 on the right, displacing the root mesially.

C. A large lateral conical mass had protruded through a posterolateral defect at L5-S1 on the right, between the dura and the nerve root.

D. A large protruded mass of degenerated fibrocartilage was found elevating the root on the right side at L5-S1.

is important. We have recently acquired a table with such rapid speed of tilt that globule formation almost always results. Proper adjustment of the pillows so that the patient assumes a modified knee-chest position tends to straighten the lumbar spine and thus prevents too rapid flowing of the opaque material in the dorsolumbar area.

The pillow is allowed to remain under the lower abdomen unless we fail to detect the presence of a defect, in which event it is usually removed. The pillow increases the intra-abdominal pressure, which in turn increases the venous pressure in the neural canal, and this may result in narrowing of the subarachnoid space. In some instances this can be readily demonstrated by having the patient breathe deeply or strain. The column may be considerably narrowed during inspiration and widened during expiration. In unusually tense or poorly relaxed patients the column tends to be narrow at first but, as the examination proceeds, the maximum width is soon noted.

In the anteroposterior view the width of the spinal canal can be accurately measured. The mesial borders of the pedicles correspond to the most lateral borders of the bony canal. The normal subarachnoid space usually fills a considerable portion of the canal, but there is a great deal of variation in this respect, and occasionally the space is very narrow. In addition to the normal width of the subarachnoid space there are regularly placed lateral projections opposite each vertebra, symmetrical on the two sides and best noted in the lumbosacral area. These lateral projections, called axillary pouches, correspond to the mesial borders of the nerve roots as they emerge from the subarachnoid space and the closely approximated dural sac. Often the nerve sheath or root sleeve is filled with the opaque medium for a short distance after the nerve has passed through the dura. Deformity of this sleeve is often of great help in detecting a lesion.

Many myelograms which were at first thought to be negative were found not to be negative when greater care was exercised in making the fluoroscopic study and in evaluating the roentgen findings. Moderate-sized protrusions, however, at the fourth and fifth lumbar or, in particular, at the fifth lumbar and first sacral interspace may frequently escape detection. This is true in patients having a narrow subarachnoid space, or where at the fifth lumbar and

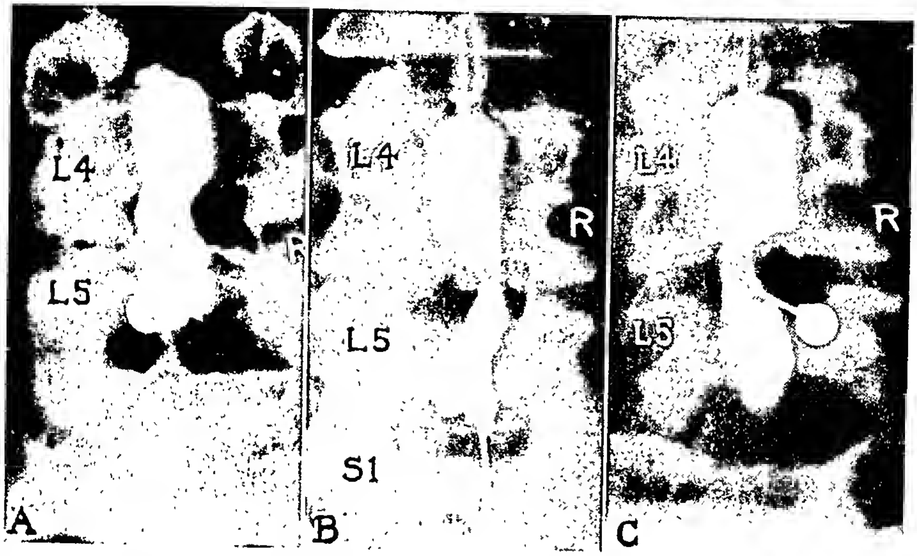

Fig. 4. Posterolateral protrusions. Disks of this type can be easily demonstrated by any contrast medium, and the clinical findings are usually typical. Only a small percentage of protruded disk defects are of this variety.

A. A large posterolateral disk on the right at L4-L5 was removed.
B. Defect at L4-L5 on the left. Three large loose pieces of fibrocartilage were found, one of which had become displaced down along the fifth root to the L5-S1 interspace.
C. Posterolateral defect on the right at L4-L5 was found to be due to a large protruded mass.

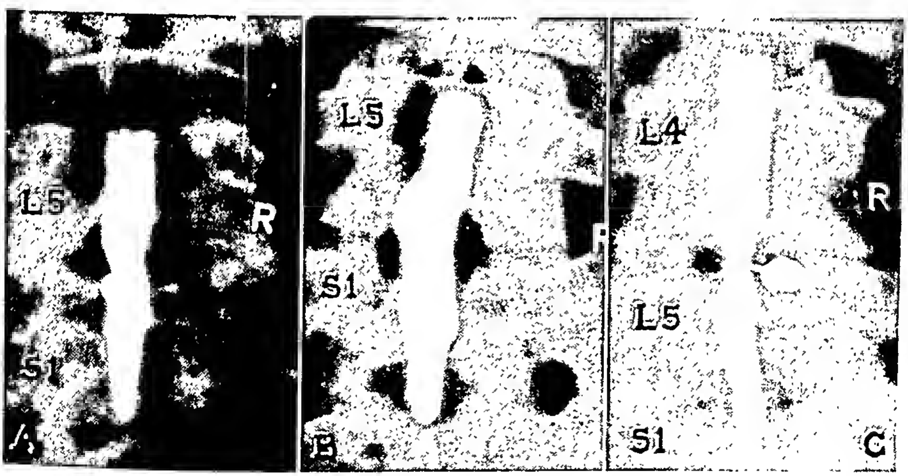

Fig. 5. Illustrating the slight deformity of the subarachnoid space when the disk is situated laterally. The nerve root may be displaced mesially against the opaque column to account for the defect. If the nerve root is displaced laterally against the pedicle, there may be typical symptoms without any deformity of the subarachnoid space.

A. Myelogram questionable at L5-S1 on the right. A large soft protruded disk was found at this level.
B. Slight but constant defect at L5-S1 on the right. A protruded disk was found compressing the nerve root mesially.
C. Myelogram questionable at L4-L5 on the left. A mass of stringy fibrocartilage was found protruding through a defect in the annulus fibrosus at this level.

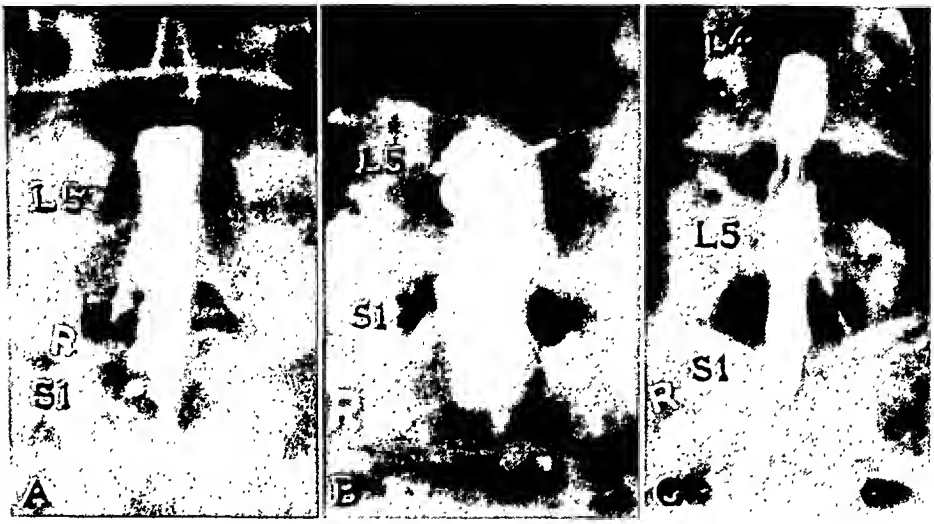

Fig. 6. Deformity of the axillary pouches or root sleeves.

A. Myelogram questionable because of the narrow column and the asymmetrically filled axillary pouch and root sleeve. A small protruded disk was found at L5-S1 on the left.

B. Myelogram shows defect at L5-S1 on the left, due to compression of the nerve root mesially and distention of the root sleeve. A large protruded mass was found adherent to the defect in the annulus and to the root, which was displaced toward the mid-line.

C. Myelogram shows mid-line defect at L4-L5 and asymmetrical filling of the root sleeves at L5-S1. A large mid-line protruded disk was removed from L4-L5. The lumbosacral space was found to be normal.

first sacral interspace a large portion of the involved nerve is outside the subarachnoid space. Partial obliteration of an axillary pouch or slight elevation of a sleeve or pouch without any indentation of the subarachnoid space may be sufficient to establish the diagnosis. These clues should be sought fluoroscopically. At times the opaque column will deviate at a certain point and there will be a visual impression of the medium flowing away from the side of the lesion more quickly than it does on the opposite side, suggesting elevation of the ventral aspect of the subarachnoid space. Only rarely does the subarachnoid space fail to extend beyond the lumbosacral interspace when the patient is examined erect and after coughing. The value of having the patient cough cannot be overemphasized. The pantopaque will flow into the sleeves and pouches through small openings because of its low viscosity.

During the fluoroscopic study at least six films are exposed to demonstrate the defect or to record the appearance of the subarachnoid space for further study. The apparatus should be such that it will permit rapid changing from fluoroscopy to radiography. Since the spinal needle is left in place during the fluoroscopic examination, it should be possible to lock the screen at a safe distance to prevent contact with the needle.

REMOVAL OF THE PANTOPAQUE

When the roentgenographic studies have been completed, the pantopaque is pooled at the tip of the needle under fluoroscopic visualization in the manner recommended by Kubik and Hampton (9) for lipiodol. The oil is aspirated with gentle suction into a 2-c.c. hypodermic syringe. Larger syringes are to be avoided as they are apt to produce too great a negative pressure, which leads either to breaking of the oil column or the sucking up of the nerve roots or membranes across the opening in the needle. With the small syringe it is not uncommon to recover practically all the opaque material at the first aspiration. When aspiration is incomplete or unsatisfactory, the fluoroscopist relocates the pantopaque adjacent to the needle tip. If cerebrospinal fluid is obtained despite

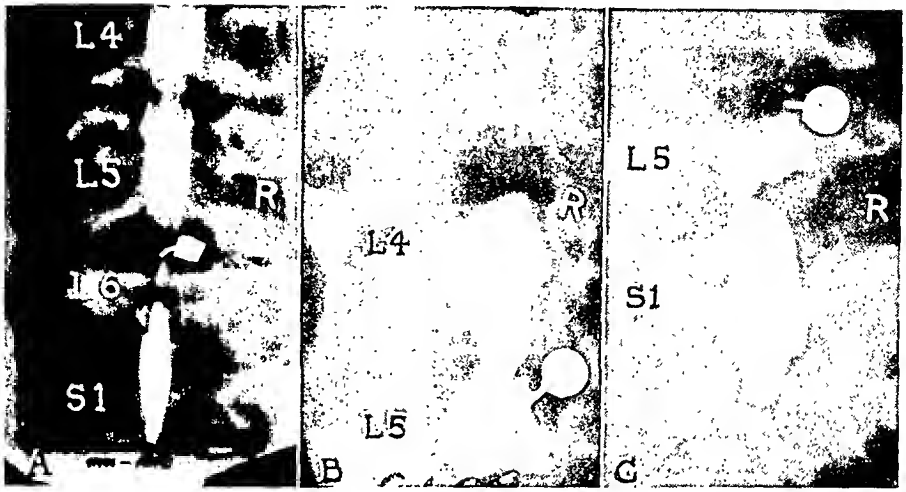

Fig. 7. Multiple disk protrusions.

A. This patient had six lumbar vertebrae. There are defects at L4-L5 on the right and at L5-L6 in the mid-line. The lumbosacral space appears normal. A small protruded disk was removed on the right at L4-L5, and a large soft mass protruding in the mid-line was found at L5-L6.

B. and C (same patient). Defects noted at L4-L5 on the left and at L5-S1 on the right. Protruded disks found at both sites.

TABLE III: REMOVAL OF PANTOPAQUE AT COMPLETION OF MYELOGRAPHIC STUDY

	Patients
Pantopaque injected	87
50% or less removed (includes 5 extra-arachnoidal injections)	10
50% to 90% removed	12
90% to 95% removed	13
95% and over removed	39
No films exposed after aspiration	13
	87

satisfactory pooling of the pantopaque, the needle is advanced until the point comes to rest in the mass of the heavier oil. Following the aspiration of the pantopaque, the needle is withdrawn and the completeness of the removal is checked by fluoroscopy and a post-aspiration film. The site of injection is covered with a sterile dressing. The entire time employed in the myelographic procedure averages twenty minutes. The patient remains flat in bed until the following day, when normal activities may be resumed.

In 70 per cent of the patients, 90 per cent or more of the opaque material was removed (Table III). It was impossible to withdraw any appreciable amount in the five instances of extra-arachnoidal injection. The factors which interfere with satisfactory removal of the pantopaque from the subarachnoid space are placing the needle at the site of the protrusion, or at a nerve sleeve, or at the periphery of the subarachnoid space so that the membranes fall against the needle opening when aspiration is attempted (Fig. 11).

SEQUELAE AND ABSORBABILITY OF PANTOPAQUE

Toxic manifestations or signs of root irritation have not been observed. The headache complained of is no more than might be anticipated in routine lumbar puncture with removal of fluid for diagnostic purposes. We have been unable to follow any of our cases in which we failed to remove the pantopaque from the subarachnoid space for a sufficiently long time to determine absorbability. Ramsey, French, and Strain (13) report that the approximate rate of absorption is 1 c.c. per year.

SURGICAL TECHNIC

The operative removal of a protruded intervertebral disk is accomplished through a unilateral approach with sacrifice of a minimal amount of bone. Adequate exposure is essential and bone is removed until this is accomplished; usually a partial hemilaminectomy is sufficient. Careful

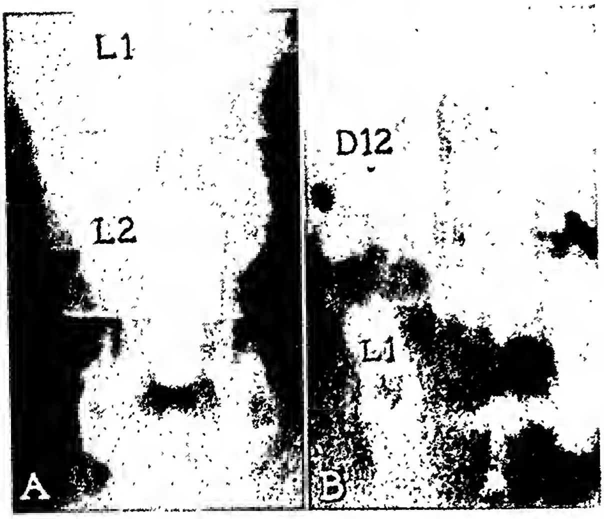

Fig. 8. Defects produced in the opaque column by tumors.

A. Complete obstruction caused by an intradural neurofibroma at L1-L2.
B. Defect due to an intradural meningioma at D12-L1.

dissection of the nerve root from the underlying disk and gentle retraction allow removal of the protruded cartilaginous mass without trauma to the nerve. The operation may be done with the patient in the horizontal or sitting position (14). When the myelogram reveals a large defect, the usual prone position is employed. We believe, however, that with a minimal defect or with no apparent myelographic change but a satisfactory clinical history, better surgical results are obtained with the patient seated. The weight of the body and the mild flexion of the trunk in this position tend to exaggerate the protrusion, thus reducing the number of so-called "concealed disks."

Spinal anesthesia is used in all cases. A mixture of pontocaine and glucose gives very satisfactory results with the patient in the sitting position, since it is heavier than spinal fluid. Muscular relaxation is improved with spinal anesthesia, thus eliminating the forceful retraction of the sacrospinalis muscle mass which is often necessary when a general anesthetic is employed. The nerve root is retracted mesially and a circular or cruciate incision is made in the posterior longitudinal ligament overlying the protrusion. The disk material is removed with a pituitary forceps. No attempt is made to remove the entire interior of the disk, but it is likely that partial removal beneath the site of the protrusion affords greater decompression of the nerve root and minimizes the possibility of recurrence. Postoperative care is symptomatic. Usually opiates are required during the first twenty-four hours because of discomfort at the site of operation. The patient is up on the third day and is fully ambulatory after one week. No postoperative back support is necessary.

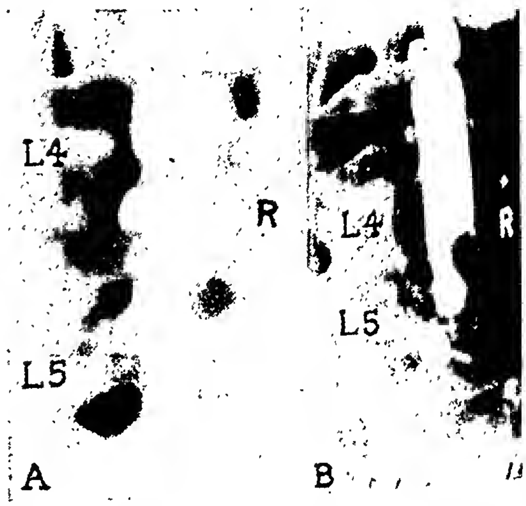

Fig. 9. Deformity of the pantopaque column not produced by disks or tumors.

A. Note defect in the lamina at L4-L5 on the right. A protruded disk was removed at this interspace one year previously. The myelogram suggested that another protrusion had occurred. Exploration revealed the tear in the annulus with considerable scarring about the area, but no new protrusions were discovered. We have recently examined two patients after disks had been removed, by using the pantopaque which was not successfully aspirated. In both instances considerable deformity of the subarachnoid space was noted at the site of the protrusion.

B. A defect is noted at L4-L5 on the right. At the exploration a hole was found in the body of the fourth lumbar vertebra about 1 cm. above the interspace, into which the forceps could be dropped easily. There was some swelling of the nerve root but no rupture of the annulus could be detected and no disk was found. To make certain that the correct interspace was explored, the space above and the space below were also explored, with negative findings.

MYELOGRAPHIC FINDINGS

(Figs. 1 to 13)

The appearance of the opaque column will usually be in accord with one of the following types:

TABLE IV: ANALYSIS OF 100 CONSECUTIVE CASES OF LOW BACK DISABILITY WITH A PROVISIONAL DIAGNOSIS OF PROTRUDED DISK ON ADMISSION TO THE NEUROSURGICAL SERVICE

Patients	Protruded Disk	Tumors	Operation		Myelogram			
			Positive	Negative	Positive	Negative	Questionable	Subdural Injection
46	49*	..	46	..	46	..	..	..
10	10	..	10	..	..	..	10	..
7	7	..	7	..	..	7	..	..
1	1†	1	1	..	1	..	..	..
4	..	4	4	..	4	..	..	..
2	..	..	..	2	2	..	..	..
3	..	..	No operation		3	..	..	..
9	..	..	No operation		..	9	..	..
5	4	..	4	1	..	..	..	5
13	11	..	11	2	Myelography not performed			
100	82	5	83	5	56	16	10	5

* Three patients with double disks demonstrated by myelography and at operation.
† One patient with disk and tumor found by myelography and surgery.

I. Mid-line defect due to rupture of the annulus fibrosus with posterior protrusion of the disk.
II. Asymmetry of the caudal end of the subarachnoid space.
III. Narrow subarachnoid space without defect.
IV. Posterolateral defects,
 (*a*) Those producing large lateral defects of the subarachnoid space.
 (*b*) Those producing very slight lateral defects of the subarachnoid space.
 (*c*) Those producing only deformity of the axillary pouches or root sleeves.
V. Obstruction due to tumors.
VI. Extra-arachnoidal injection.

DISCUSSION

Myelography not only affords an easy method of investigating the cauda equina but also allows accurate visualization of each lumbar interspace. Pantopaque has proved to be an excellent medium for this purpose and affords satisfactory contrast. Multiple protrusions have been observed when a single lesion was suspected clinically. Tumors have been found when a protruded disk was believed to be present, and in one instance a tumor and a large protruded disk were found in the same patient.

The complaints associated with protruded disks are often out of proportion to the clinical findings. Objective findings are not uncommonly vague or absent. Frequently the complaints are typical of a protruded disk but the neurologic findings are scant and indefinite. If, however, the same patient is examined a week or so later, very definite neurologic findings may be elicited, including absence or diminution of reflexes which were normal at the previous examination.

A total of 82 protruded disks were removed from 79 of the patients in our series (Table IV). Three patients each had two disks. Three patients had definite neurologic and myelographic evidence of protruded disks but were not operated upon. An operation was performed in 13 instances without myelography and in 2 of these patients findings sufficient to explain the clinical picture were lacking. Two patients had myelographic evidence of disk protrusion, but a protruded disk was not found at operation (Fig. 9). Protruded disks were either diagnosed or strongly suspected in 57 of the group of 87 patients on whom myelography was performed. In 10 of these cases the myelographic evidence alone was questionable, but its correlation with the neurologic data made an exact localization possible. In 7 instances myelographic evidence of disk protrusion was lacking. The opaque material was injected outside the subarachnoid space in 5 patients, apparently due to faulty technic.

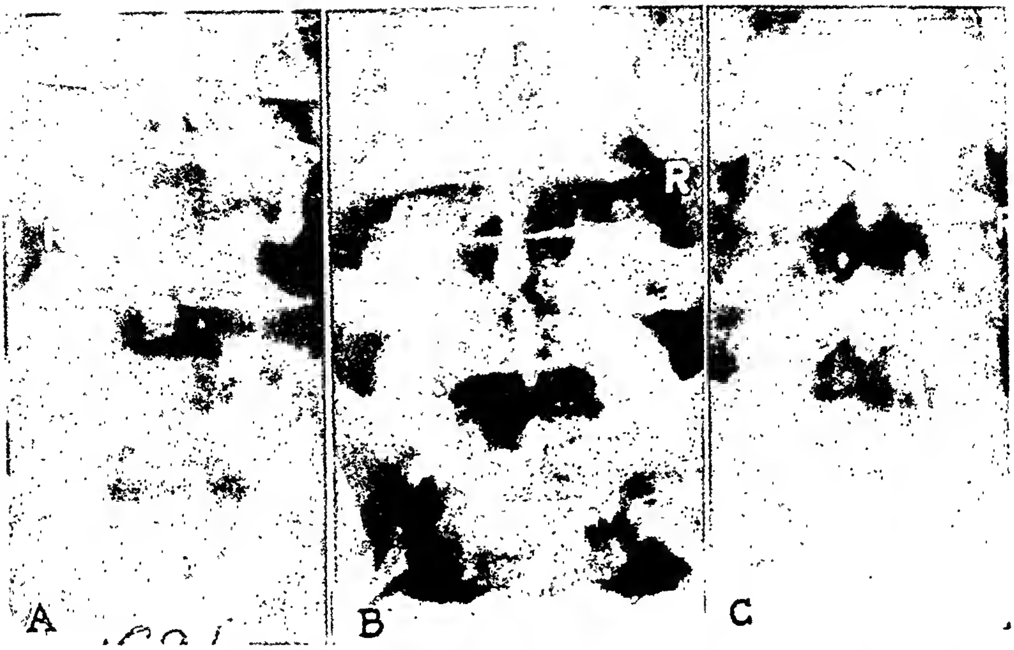

Fig. 10. Successful removal of pantopaque by aspiration.

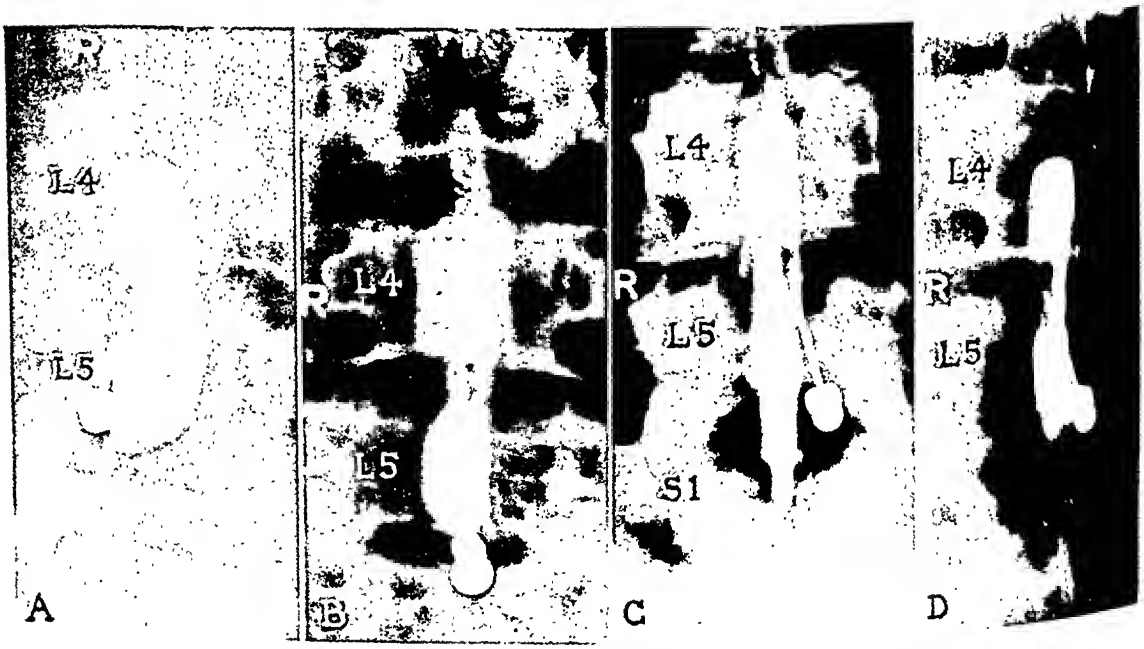

Fig. 11. Common causes of unsuccessful aspiration of pantopaque.

A. The needle was placed at the periphery of the subarachnoid space so that the meninges covered the needle opening when aspiration was attempted and none of the opaque material was recovered.

B. Only 25 per cent of the pantopaque was recovered. Note the indentation of the column at L4-L5, due to the bulge of the normal intervertebral disk. Globule formation is present.

C. The needle had been placed adjacent to the root sleeve and none of the pantopaque was recovered. This patient had sharp pain radiating down the left leg when aspiration was attempted. Note the narrow column with a wide space between the pedicles and the subarachnoid space.

D. Only a small amount of the pantopaque was recovered due to the needle having been placed adjacent to the protruded mass.

We have accumulated no evidence that such leakage follows a recent lumbar puncture and we have made no attempt to postpone myelography if lumbar puncture has recently been performed. All but one of the protruded disks were caudal to the fourth lumbar vertebra (Table V). Five tumors were found and 4 of them were above the body of the fourth lumbar vertebra and below the body of the eleventh dorsal vertebra.

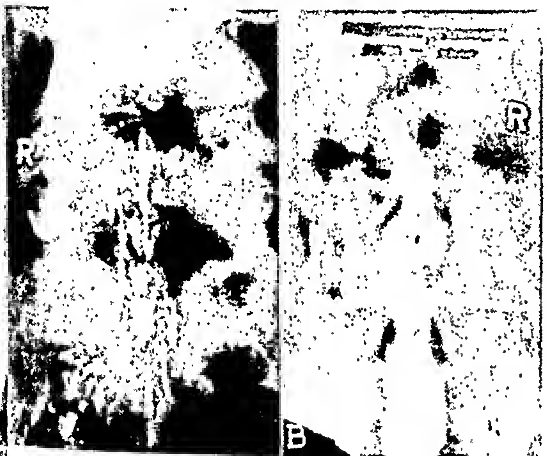

Fig. 12. Typical appearance noted after injection of pantopaque outside the subarachnoid space.

A. This was the appearance noted at the start of the fluoroscopic study. The pantopaque remained in the pattern demonstrated and none of it was recovered by attempted aspiration.

B. The opaque material remained in this compact mass and would not flow up or down the neural canal. A lateral film demonstrated that the material was confined to the dorsal part of the neural canal.

It is not the purpose of this paper to consider the instances in which the roentgenologic and neurosurgical findings were in accord but rather to re-examine those in which the roentgenologic findings were negative or questionable and the surgical findings were positive. Early in our experience with pantopaque it became evident that those persons having a narrow subarachnoid space offered the greatest diagnostic difficulties. We have reviewed the myelograms in the present series of cases and have made interpediculate measurements and measurements of the subarachnoid space at its normal width nearest to the defect. Since a cross-section of the lumbar dural sac is triangular, with the base of the triangle ventrally, the measurement of the subarachnoid space is not altered by changing the patient from the prone to the erect position. Figure 14 demonstrates the relationship of the width of the subarachnoid space to the positive operative findings. It is evident that those patients having questionable or negative myelographic findings with subsequent positive surgical findings all fall into the group having a narrow subarachnoid space. Discrepancies occurred only when the subarachnoid space measured 16

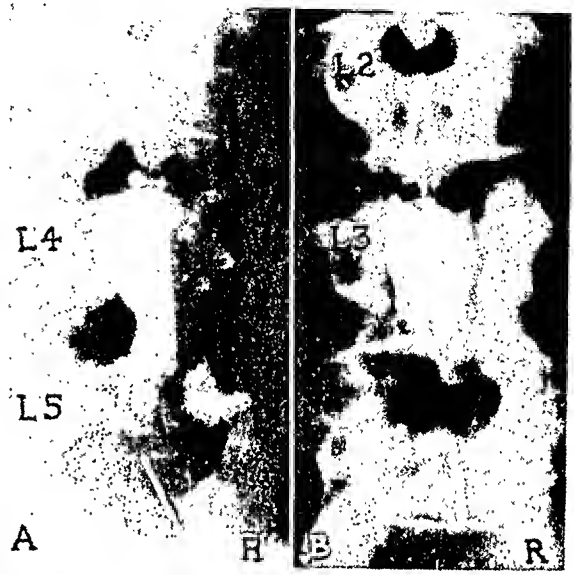

Fig. 13. Tumor of the cauda equina and a protruded disk in the same patient.

A. A large defect was demonstrated at L4-L5 on the left side.

B. Same patient as A. In the attempt to carry out our routine study of the neural canal by running the opaque material as far cephalad as the tenth dorsal vertebra, a complete obstruction was discovered at L2-L3. At operation a large posterolateral protrusion was found at L4-L5 and a neurofibroma measuring 2.5 × 1.5 × 1.5 cm. was found at L2-L3.

TABLE V: LOCATION OF PROTRUDED DISKS AND TUMORS

Protruded Disks	Right	Left	Mid-line
L3-L4	1	0	0
L4-L5	15	14	7
L5-L6	0	0	1
L5-S1	21	23	0

Tumors	Histologic Type
D12-L1	Meningioma
L1-L2	Neurofibroma
L2-L3	Neurofibroma
L3-L4	Ependymoma
L5-S1	Neuroepithelioma

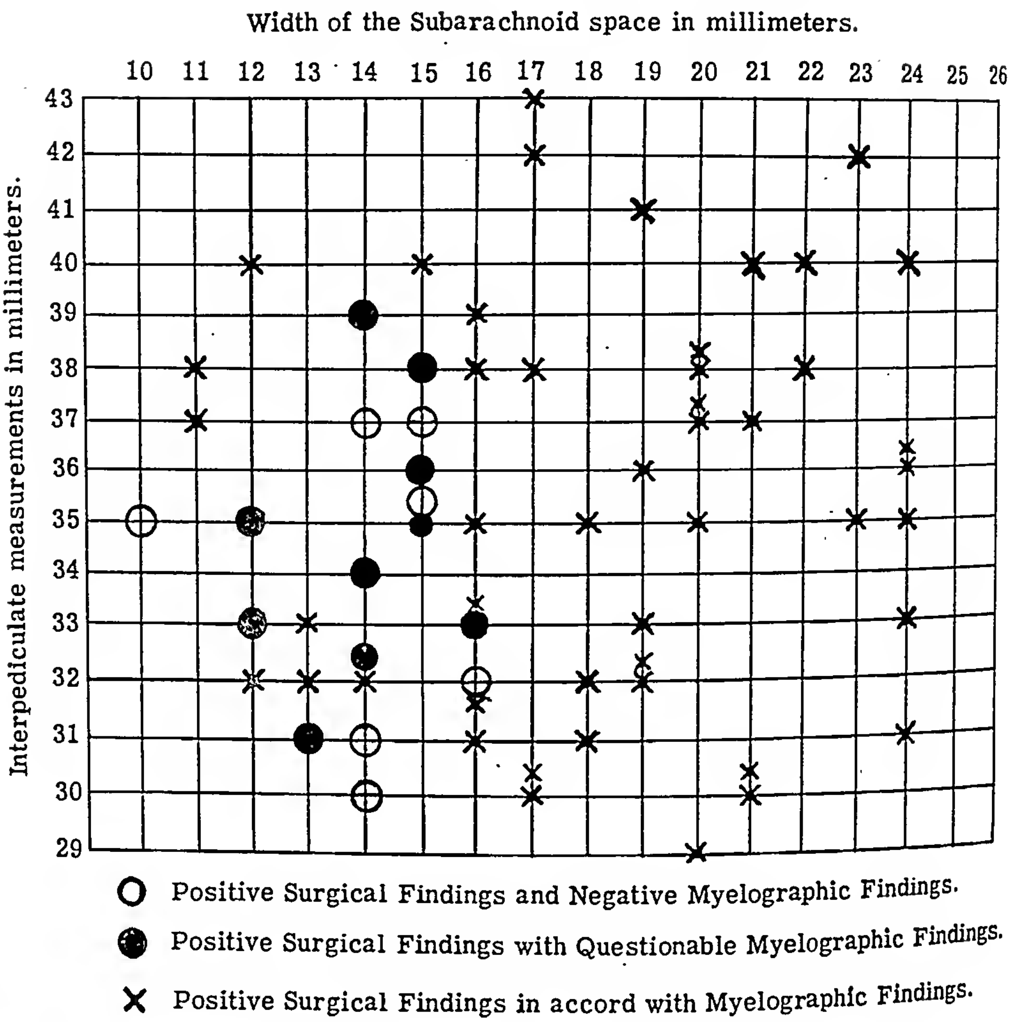

Fig. 14. Relationship of width of subarachnoid space to operative findings.

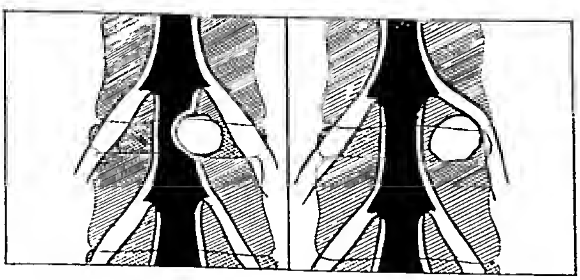

Fig. 15. Possible location of protruded disks in relation to the opaque column and nerve roots.

mm. or less. There was complete confirmation of the roentgen findings in all patients having a subarachnoid space wider than 16 mm. The interpediculate measurements have no bearing on the width of the subarachnoid space. Even with a narrow subarachnoid space, mid-line or large posterolateral protrusions offered no diagnostic difficulties. Failure to demonstrate the lesion occurred in patients having a narrow subarachnoid space and a small posterolateral protrusion which failed to indent the column of pantopaque. In addition, posterolateral protrusions which fail to encroach on the nerve sleeves or pouches, or in which these structures do not fill, will not be detected by myelography. Our explanation of the lack of positive myelographic findings in instances of narrow subarachnoid spaces is that the distance between the site of the rupture and the subarachnoid space is sufficiently great to allow moderate protrusions without indentation of the opaque column (Fig. 15).

It must be admitted that with our present technic not all protruded disks can be demonstrated. The myelographic procedure is worth while, however, in ruling out

lesions of the cord and cauda equina. This permits surgical exploration at the interspace where the disk is localized clinically. When the operation is done through a small opening, a shorter period of hospitalization is required and the future usefulness of the patient to the Navy will not be jeopardized.

CONCLUSIONS

1. Roentgenograms of the lumbosacral spine without the aid of myelography are of little definite value in the diagnosis of protruded intervertebral disks.

2. In our experience, pantopaque has been found to be a satisfactory medium for myelography because of ample contrast, lack of irritating properties, low viscosity, and ease of removal.

3. Despite the fluidity and low viscosity of the medium, which allows it to fill all irregularities of the dural sac, many protruded disks cannot be detected with our present technic.

4. Pantopaque myelography should be carried out routinely as an aid in the diagnosis and localization of protruded disks and to rule out tumors of the cord, meninges, and cauda equina.

5. It is demonstrated graphically that a negative myelogram in a patient whose subarachnoid space measures less than 16 mm. does not preclude the presence of a protruded disk.

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Pantopaque Myelography for Protruded Disks of the Lumbar Sp

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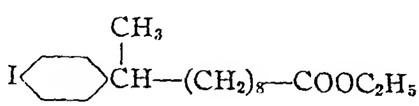
THE VALUE AND limitations of myelography for the diagnosis of intraspinal lesions are becoming well recognized. Pantopaque (6, 10) as a contrast medium was first introduced into the Army hospitals in 1942 by Spurling (9). Constant search is being maintained for a contrast medium that is innocuous, absorbable, and capable of being easily removed, so that no foreign body material may remain within the spinal canal. These demands seem to be best met at present by pantopaque. The indications for the employment of such an oil depend on the diagnostic problems at hand. Obviously its indiscriminate use is to be discouraged when an accurate diagnosis can be reached clinically. However, to have available a substance that is safe and that can aid in the determination and more accurate localization of a suspected intraspinal lesion is of definite advantage.

CHEMISTRY (11)

Pantopaque is a mixture of isomeric ethyl esters of which the principal constituent is provisionally ethyl iodophenylundecylate:



It is prepared by esterification with ethyl alcohol of the mixture of iodophenylundecylic acids obtained by direct iodination of phenylundecylic acid. The ester is purified by treatment with decolorizing agents and by distillation under reduced pressure. The final product contains 30.5 per cent of iodine in firm organic combination and has a specific gravity of 1.26 at 20° C. It is a colorless to pale yellow liquid which does not deteriorate on stora which may be sterilized. It is disc however, by exposure to sunlight. paque is deleterious to rubber artic should not be brought in conta them. It is practically non-miscib water or spinal fluid.

TECHNIC

A procedure remains standard principle and is usually modified to the requirements or convenience o operator (6, 9). The technic outline is in essence that being employed by neurosurgeons in military hospitals, it has been used for some time.

The patient is prepared by a cl enema six to ten hours before the exam tion is to be made, and aspirin 0.6 gm. gr.) and seconal 0.1 gm. (1 1/2 gr.) given two hours prior to the procedure. The lumbar area is shaved and cleansed as necessary. The patient is then placed prone on a tilting fluoroscopy table with a small pillow under the lower abdomen to facilitate spinal puncture. (If desired, a spinal puncture can be performed in the lateral recumbent position and the patient then carefully turned onto the abdomen.) The feet should be resting firmly against the foot board for support when the table is tilted downward. The lumbar spine is then prepared and draped, and novocaine is infiltrated into the interspinous space selected.

The spinal puncture is made preferably either above or below the interspace at which the lesion is suspected. The level of the suspected lesion is avoided for three reasons: (a) the needle may strike the lesion itself and so enhance or distort the

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g. 1. Normal myelogram showing good visualization of nerve root sleeves.

Fig. 2. Extensive globulation in an otherwise normal myelogram.

onormality; (*b*) the injection and subquent removal of the oil may be more ifficult; (*c*) an artefact is occasionally eated in the canal at the site of the puncre that might lead to an erroneous conlusion, as shown in Figure 5. The exact ause of such an artefact is not known, but is thought to be produced by the peneation of the dorsal dural envelope by the eedle, the dura being indented and pushed way from the canal wall, thus giving the ppearance of an extradural mass on either ide of the canal. This is particularly true the needle is not exactly in the mid-line. bviously, in questionable cases removal f the needle and re-examination will settle he question.

A 20-gauge lumbar puncture needle is arefully inserted into the mid-line of the pinal canal until the point just touches he ventral canal wall (to facilitate subsequent removal of the oil) and then rotated or manipulated until fluid escapes from the head of the needle, as it does readily. Five c.c. of spinal fluid are aspirated with a syringe for laboratory analysis. This helps, also, in determining a good free flow of fluid and the absence of obstruction at the needle point, conditions which are necessary for ready removal of the pantopaque at the close of the examination. The pantopaque (3 c.c.) is then taken up in a 5-c.c. Luer-Lok syringe and the syringe is locked onto the spinal needle. With firm steady pressure, the entire quantity of oil is injected under pressure just sufficient to effect its ejection into the canal in a constant stream rather than by droplets. This tends to insure the oil remaining in one large mass and there is less tendency to "globulate" in the canal (Fig. 1). The syringe is then disconnected; the stylet is

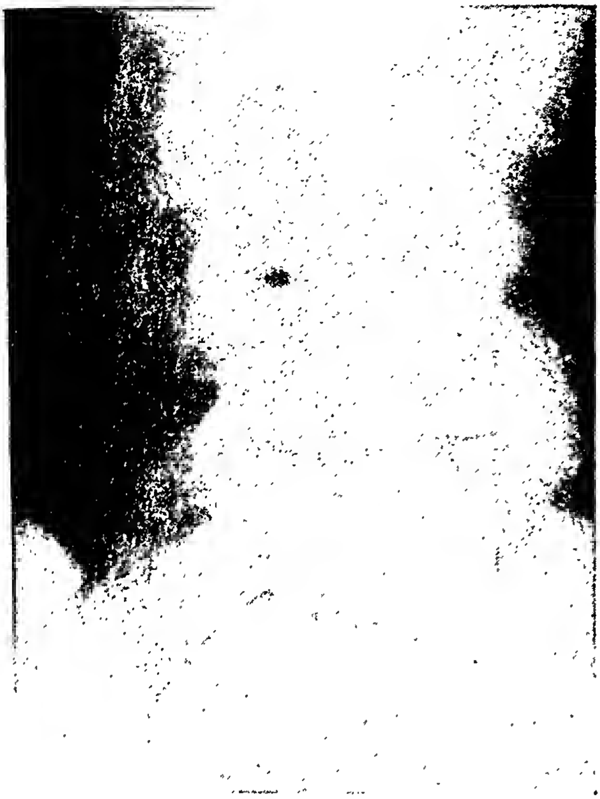

Fig. 3. Pantopaque collected at the needle point, ready for removal.

inserted into the needle, which is left *in situ* and covered with a sterile towel.

Fluoroscopy is then carried out, slowly tilting the patient up or down and observing the column of oil moving along the canal. It is important to tilt the patient slowly, since rapid movement of the oil tends to cause it to break up into globules (6) (Fig. 2). The maximum information is obtained from the examination by observing the "head" of the column of oil as it becomes deflected by any abnormal mass lying within the spinal canal. Normally, the oil flows smoothly in the canal and fills out the root sleeves well. For the confirmation of a defect, the patient can be rotated from side to side, particularly in the presence of lesions lying along the ventral canal. When a lesion is adequately demonstrated, proper views are made on films and examination is then complete.

The following factors were employed for fluoroscopy: 0.5 mm. aluminum inherent in the tube, with 5 ma. at 70 kv.p. In the radiographic technic for the posteroanterior view the factors were: filter, 1.5 mm. aluminum inherent in the tube; target distance 36 inches; 100 ma.; 1 1/2 seconds; 67 kv.p. For the oblique view the filter and distance were as above, but the kilovoltage was increased to 74 kv.p. These represent average technic, with the use of a Potter-Bucky diaphragm. When possible, "spot" films of the protruded disk should be made immediately after fluoroscopic demonstration of the disk.

The removal of the oil from the canal requires some ingenuity on the part of the fluoroscopist as well as the surgeon. The procedure is a bit tricky, but not difficult, as is shown by the fact that as the experience of the operators—surgeon and fluoroscopist—increases, the oil is removed more readily and more completely. In instances in which the spinal needle has been inserted into the L5 interspace (as for lesions suspected at L3 or L4), the feet are tilted downward until the lower part of the oil mass is pooled about the point of the needle (Fig. 3). The 5-c.c. Luer-Lok syringe is reattached, and the oil is aspirated by constant slow suction. As the oil comes into the syringe, the fluoroscopy table is tilted slowly (feet downward) and the oil is removed as one would empty a barrel through a spigot. When the needle is at the L3 or L4 interspace, the oil is placed with the needle at its center and the table tilted up or down as is necessary.

On removing the stylet from the needle preparatory to attaching the syringe for aspirating the oil, one can readily tell whether oil or spinal fluid will be obtained on aspiration. If oil surrounds the point of the needle, there will be no free flow of fluid, whereas if the oil has not been properly placed, spinal fluid will flow freely. In some instances, a moderate degree of patience and persistence is necessary for removal of all the oil. At times, removal can be facilitated by having the patient exhale with the closed glottis (Valsalva experiment) (7).

There is another procedure which is slightly easier, particularly if a spot-film device is used on a fluoroscopy screen. It avoids the possible danger of pressure by

Fig. 4. True defects in pantopaque produced by a protruded disk.

he screen on the spinal needle and facili-ates rapid filming as pantopaque flows hrough the spinal canal. L3 puncture echnic is carried out with the patient on his side, which is usually easier than the rone position procedure. A spinal fluid pecimen is taken and pantopaque is in-ected rapidly. The needle is withdrawn nd the patient is then placed in the prone osition and fluoroscopy and radiography re performed by the previously described r spot-film technic. The following factors re used in the spot-film fluoroscopy appa-ratus (Keleket): for fluoroscopy, 4 ma., 5 kv.p., 1 mm. Al on the large spot of the ube; for radiography 1/2 second expo-ure, 100 ma., 67 kv.p. (average), 1 mm. Al n the large spot of the fluoroscopy tube or the anterior-posterior view on a 5 × 7-nch cassette. If there is no L5 defect, an L5 tap is done with the patient on his side nd he is carefully turned onto his ab-lomen. The foot of the fluoroscopy table is then tilted downward, the pantopqaue pools almost automatically around the needle point, and removal is easily accomplished. This procedure has the disadvantage of requiring two lumbar punctures and may be difficult or impossible in the presence of L5 defect or complete block above it. However, re-tap can be done in the original interspace and the usual pooling carried out with the aid of fluoroscopy.

When the technic of myelography is carried out carefully, the procedure is relatively painless; it can be completed in twenty to thirty minutes, and fairly accurate positive or negative objective evidence can be demonstrated (Fig. 4).

CLINICAL STUDY

The rigid training program instituted by the Armed Forces for the physical development of the men to endure the rigors of combat duty brings to light many cases of

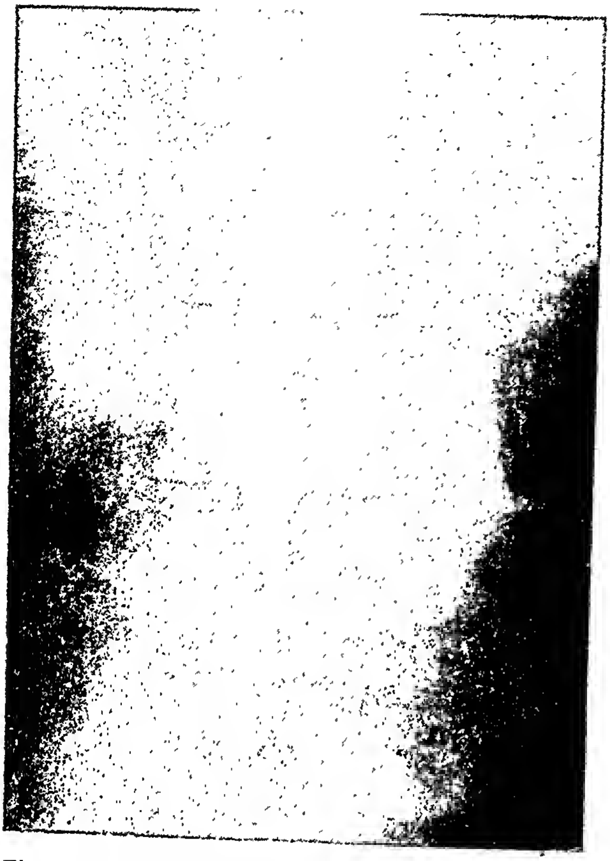

Fig. 5. False positive disk, an artefact produced by the needle.

latent and manifest "low back pain." The more severe cases, incapacitating the patient for active duty, are usually referred to the Army general hospitals for definitive care and final disposition. At the time of this study there had been admitted to the Surgical Service of Bushnell General Hospital a total of 312 patients with "low back pain," with or without sciatic radiation. Most of the patients have been seen and treated conservatively (without operation) in the Section of Orthopedic Surgery; the remainder, in whom protruded intervertebral disks were suspected, were treated by the Section of Neurosurgery. Since the responsibility of the Army is limited to injuries incurred in line of duty, only those cases of questionable diagnosis, acquired in line of duty, and those cases requiring a more specific diagnosis than merely "low back pain with sciatica," for review before a disposition board, were subjected to special examination by pantopaque myelography. We have selected for this study the first 100 consecutive cases in which myelography was done.

In the group of 100 cases studied, 30 (30 per cent) showed definite myelographic evidence of a protruded disk. Thirty-seven patients were operated upon, including 5 with a false negative myelogram and 2 with a false positive defect. All the operated cases were in line of duty. Of the 30 patients with myelographic evidence of a true protruded disk, 3 (10 per cent) had multiple protrusions that were disclosed only by the aid of myelography.

Various studies have been made on the relationship of a narrowed intervertebral disk space to low back pain. Hodges and Peck (6) estimated that a narrowed disk space (lumbosacral joint) occurred in 57.2 per cent of 447 patients having low back pain with sciatic radiation. But no mention was made of verified protruded disks in this series. It was further pointed out by Hodges and Peck that "a narrow disk is undoubtedly to be expected in the case of patients showing evidence of bilateral or even unilateral fusion of the fifth lumbar vertebra with the sacral mass." Dandy (3) maintains that the diagnosis of a protruded disk can be made in over half the cases from x-ray examination of the lumbar spine alone. In view of these facts, we carefully reviewed the preoperative flat x-ray films of our 35 verified operated cases for evidence of a narrowed space at the level of the disk removed. In only 7 cases (20 per cent) did we find a definite narrowing that could be considered to be of diagnostic value—two L4 disks and five L5. With the preponderance of protruded disks occurring in the lower lumbar region, definite evidence of a narrowed disk space would be very helpful in establishing the diagnosis. But the normal variations that occur, particularly in the angle of the fifth lumbar with the first sacral body and the apparent "wedging" of the intervening disk, may be misleading (4, 13). We agree that different reports will vary (5) and that our series of 35 verified cases is too small to be of statistical importance.

In a careful study of the 100 myelograms

18 cases were found to show a false defect on the film due to the presence of the needle in the canal, as pointed out earlier (4). Of these 18 cases, 2 early in the series were operated upon with negative findings, after which we awoke to the fact that the needle itself can produce a defect that closely simulates an extradural mass such as a protruded disk (Fig. 5). These we call "false positive disks." Conversely, in the series of 100 cases were 5 presenting the classical disk syndrome but showing a normal myelogram. These 5 patients were operated upon, and in each a protruded disk was successfully removed. Such cases, with negative myelographic evidence but positive clinical findings we call "false negative disks."

Total withdrawal of the pantopaque becomes easier with experience. In our hands it seems to be best accomplished when the spinal tap has been made at the L3-L4 interspace, which is usually above the protruded disk level (4). In 68 per cent of the cases the pantopaque (3 c.c.) was removed completely. In 14 per cent of the cases less than 0.5 c.c. of the oil was retained in the canal and could not be removed. In 15 per cent of the cases between 0.5 and 1.5 c.c. could not be withdrawn, due to globulation and scattering of the oil within the canal. In a few instances (3 cases) the oil was "caught" in the nerve root sleeves, making its removal impossible (Fig. 6).

That iodinated compounds cause a slight reaction in the intraspinal spaces has been reported both experimentally and clinically (1, 2). The fact that practically all the pantopaque was removed within a half hour after its injection in most of our cases (82 per cent) obviates much chance for a reaction. In 10 cases with retention of oil in amounts ranging from 0.1 to 2.0 c.c., lumbar punctures done at varying intervals (one to four days) after instillation of the pantopaque showed that reaction, when present, was not directly proportionate to the amount of oil retained. Seven of the 10 cases studied showed no reaction or alteration in the spinal fluid analysis. In the remaining 3 there were signs of a meningismus, with headache, generalized aching, and slight temperature elevation, that subsided in seventy-two hours. The case with the largest retained quantity of oil (2 c.c.), showed 172 cells and a total protein of 90 mg. in the spinal fluid. Another case, with a retention of 0.5 c.c., showed 126 cells but no elevation of total protein. The third case, with a residual of 0.25 c.c., showed 1,120 cells and a protein elevation of 110 mg. per cent. In all 3 of these cases lumbar puncture was done at twenty-four hours after myelography. All fluids were cultured and showed no growth of organisms. All patients made a rapid and uneventful recovery clinically and as shown by seventy-two-hour spinal fluid studies.

Fig. 6. Pantopaque spread into nerve root sleeves, with possibly some in the extradural space. No reaction or symptoms.

We have not had the opportunity to determine the possibility of absorption of pantopaque within the spinal canal, but the opinion has been expressed that the oil is absorbed at an estimated rate of 1 c.c. per year (6, 14). This fact should not

deter one from making every effort to remove all oil possible. We found evident reaction in only 3 of the 100 cases, but this is actually 9.4 per cent of the 32 cases in which some oil was retained. These 100 myelograms were done by 10 different officers with varying experience, and results became better as each individual's technic improved.

SUMMARY AND CONCLUSIONS

In a series of over 300 patients complaining of low back pain and sciatica, pantopaque was utilized as a contrast medium to aid in the diagnosis of 100 cases, which are here reported. We believe pantopaque to be the best substance for contrast myelography so far discovered. We feel it to be superior to lipiodol and air for myelography because of the ease of intraspinal instillation and of removal and because of its accuracy in delineating intraspinal lesions. It should be utilized as an aid in diagnosis but not as the final answer in all cases, particularly in the event of "false negatives."

Of the 100 cases reviewed, 30 showed a positive defect verified at operation. Thirty-seven patients were operated upon, with removal of a disk in 35. In 2 cases exploration failed to reveal any lesion, the "false positive" defect being due to the needle left in place at the time of myelography. In 5 cases in which myelography failed to demonstrate a protruded disk, one was removed at operation. Three patients (10 per cent of 30 positive myelograms) had multiple protruded disks, demonstrated only by the aid of myelography.

Pantopaque produced a reaction in 3 of the 100 cases, manifested by symptoms of meningismus and an elevation of the cell count and (in 2 instances) total protein in the spinal fluid. Rapid recovery followed without sequelae. Since the needle used for instillation in this technic is usually left in place as a matter of convenience, it has been pointed out that an artefact can be produced in the pantopaque column that may be erroneously interpreted as an extradural mass.

The verification of the presence of a protruded intervertebral disk or other suspected intraspinal lesion, as well as its accurate localization and the finding of an occasional additional unsuspected disk, makes the use of pantopaque in lumbar myelography advisable in indeterminate cases of low back pain with sciatica.

NOTE: We wish to acknowledge our appreciation to the following men who have been associated with the Radiological Section: Lt. Colonel F. P. Carrigan, Major M. L. Jacobs, Captain E. A. Addington, Captain Sam Meltzer.

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Beneficial Effects of Roentgen Therapy in Advanced Cases of Rheumatoid Arthritis

Preliminary Report[1]

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ROENTGEN RAYS have been used for the treatment of joint diseases for many years. The earliest published report is that of Sokoloff (Russia) in 1897. Practically all types of joint involvement have been treated. There are reports of roentgen therapy in gonorrheal arthritis (Wetterer, Kaplan), in tuberculosis (Iselin, Jüngling), in gout (Albers-Schönberg), in osteo-arthritis (Staunig, Kahlmeter, Swaim, Goldhamer), and in hypertrophic spondylarthritis (Köhler, Kelly). Favorable results have been reported in all these conditions, but in the rheumatoid (atrophic, proliferative) types of arthritis roentgen therapy has been regarded as less satisfactory. Watt (England), in 1932, wrote: "In hypertrophic arthritis, radiation is the treatment of choice; in the atrophic type, little or no benefit can be expected." Smyth, Freyberg and Lampe, in this country, reported their results in rheumatoid arthritis as "so discouraging that we abandoned this treatment."

Favorable results have been obtained in Marie-Strümpell disease by Scott, Oppenheimer, Hare, Smyth, Freyberg and Peck, Rees and Murphy, and others. The term Marie-Strümpell disease, however, is used variously by different writers. There is an earlier stage in which the spine alone is affected and a later stage in which the hips, shoulders, and other peripheral joints are also involved. In all the reports on roentgen therapy of the disease, only the spinal manifestations are considered. This gives rise to the impression that there is a difference between the vertebral joints and the peripheral joints in rheumatoid arthritis in their response to x-rays. This has not been our experience. We have not found it a general rule that rheumatoid arthritis of the spine responds to roentgen therapy while rheumatoid arthritis of the peripheral joints does not. We have obtained beneficial results in rheumatoid arthritis, the response to radiation depending upon the stage of the disease and the dosage.

PRINCIPLES AND TECHNIC OF ROENTGEN THERAPY IN RHEUMATOID ARTHRITIS

Rheumatoid arthritis can be divided into three main stages, each of which must be differentiated from the others. The most valuable criterion of differentiation is the degree of impairment of mobility, which is easily determined clinically. In the *first stage*, pain and soft-tissue swelling restrict the active mobility of the joint, though passively it can be moved through its full range. In the *second stage*, mobility is restricted both actively and passively to a varying degree. In the *third stage*, no motion either active or passive is possible.

Roentgenographically, in the *first stage*, the joint space is of normal width; there may be an effusion or swelling of the periarticular tissues and some decalcification of the bones. In the *second stage*, there is usually a narrowing of the joint space, and sometimes destruction of the subchondral adjacent bone. In the *third stage*, the joint space may be obliterated, with an osseous

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ankylosis or a pronounced thinning of the articular cartilages associated with a fibrous ankylosis.

Pathologically, "in the early stages, the cartilage may appear nearly or quite normal, and the only visible change may be in the synovial membrane" (Nichols and Richardson). This is hyperemic and edematous, and an effusion is present, as well as periarticular soft-tissue swelling. The edematous phase is followed by signs of an inflammation of a more chronic nature. Fibrin is precipitated and tends to cause adhesions. The synovia becomes thickened because "almost from the beginning there is a constant increase in the number of fibroblasts" (Jordan). The lymphatics are obliterated (Kuhns), causing a retention of intra-articular fluid. This phase passes imperceptibly into that of hyperplastic change. "The synovial villi and the synovial lining cells proliferate" (Fisher). Thus, the *first stage* is characterized pathologically by a succession of edema, chronic inflammation, and hyperplasia of the synovial membrane.

The *second stage* is marked by the formation of granulomatous tissue, as described by Nichols and Richardson. This tissue is composed of lymphocytes and their derivatives. It fills the joint spaces with a pannus and then covers the articular cartilages, binding them together and eventually destroying them with the aggressiveness of a tumor. At the same time, the granulomatous tissue is gradually transformed into fibrous tissue, resembling, in this respect, a keloid, hyperplastic granulation tissue. It is the presence of the granulation tissue which gives rise to the designation "proliferative arthritis." Thus, the *second stage* is characterized pathologically by the presence of granulomatous and fibrous tissue.

The *third stage* is that of destruction of the cartilages and their replacement either by fibrotic strands or osteoid tissue, with complete ankylosis as the end-result. The joint space finally becomes obliterated. In the completely ankylosed joint granulation tissue may persist in the capsule, being responsible for the pain, spontaneously and on pressure.

Because of the pathological differences, the various stages of rheumatoid arthritis are of varying radiosensitivity. Different doses of radiation are required to influence an inflammatory edema, a chronic inflammation, a hyperplasia, and granulomatous tissue. The following depth doses have been found effective:

Inflammatory edema	50–100 r in 1 session.
Chronic inflammation	200–300 r in 1 to 3 sessions.
Hyperplasia	800–1,200 r in about 3 weeks.
Granulomatous tissue	1,200–1,600 r in about 3 weeks.

Since February 1942, these standards of dosage have been adhered to in treating rheumatoid arthritis in the Roentgen Department of the Goldwater Memorial Hospital. This is a municipal institution for the treatment of chronic diseases. There are no direct admissions to the hospital, but all patients are transfers from other hospitals in New York City or from the Welfare Island Dispensary. Our series of arthritic patients, therefore, had received practically all of the accepted methods of treatment prior to hospitalization in the Goldwater Memorial Hospital. Upon admission they were again subjected to a number of therapeutic procedures, such as gold therapy, physiotherapy (heat, massage, whirlpool), drugs, and orthopedic measures. Many had been treated with vaccines, and a few surgically. When all of these measures failed to produce or maintain a noteworthy result, the patients were referred for roentgen therapy. Thus, they represent selected material marked by the two following facts:

1. All of them had been suffering from their condition over a period of years.

2. All of them had undergone a variety of treatments which had failed to arrest the disease process.

All patients were in a more or less advanced stage of rheumatoid arthritis. Very few were in the first stage or showed symptoms of the inflammatory phases, though these developed in previously uninvolved joints during the stay in the hospital.

As a consequence, the majority of patients received dosages which ranged between 800 and 1,600 r. The dose was usually administered within a period of three weeks. In our experience this was the shortest period in which the treatments could be given to a joint without damage to the tissues. The factors used were 200 kv., 20 ma., 50 cm. distance, 0.5 mm. Cu + 1.0 mm. Al filtration, with a half-value layer of 0.9 mm. Al. The size of the port depended upon the area treated. Each port was treated three times a week, and the amount delivered daily depended upon the part, the area, and the size of the port. Some joints were treated through two and others through three ports at each session. Most cases received their full course of treatment in eight sessions to any one joint. Where multiple joints required treatment, two joints were treated alternately, so that the patient actually received treatment daily, except on Sundays and holidays. If all joints were affected, the body was divided into fifteen different treatment areas as follows:

	Number of Areas
Fingers of both hands and wrists	1
Elbows	2
Shoulders	2
Toes	1
Ankles	1
Knees	1
Hips	2
Lumbosacral spine	1
Dorsal spine	1
Cervical spine	1
Temporomandibular joints	2
TOTAL	15

Bilateral affected parts that could be treated simultaneously were considered as one area. When two corresponding joints differed considerably in the stage of disease, they were treated separately.

It was calculated that the treatment of all areas according to our method would require a period of about twenty-four weeks. This is not recommended. Most of our patients received therapy to six areas only during any one course of treatment.

To date we have treated 66 cases. Of this group we have selected 10 for critical study, as shown in Table I. These patients had the disease for at least two years prior to roentgen therapy and had been subjected to the usually accepted types of therapy for rheumatoid arthritis. Some of the spinal joints as well as the peripheral joints were involved. Radiation was given as indicated above. At least two years have elapsed since the roentgen treatment was completed. The number of the joint areas treated in these 10 patients totals 85.

RESULTS OF TREATMENT

Beneficial results have been obtained with roentgen therapy in a number of patients suffering from rheumatoid arthritis. Some who were incapacitated by the disease and hospitalized for a number of years improved to such an extent that they were discharged from the hospital and were able to resume either all or some of their previous activities. Some discarded their crutches and canes and were able to walk without assistance. Pain and muscle spasm diminished in some and disappeared in others. Many patients who could not raise their arms to shave or comb their hair, who could not bend to tie their shoes, who could not sleep, and breathed only with difficulty because of pain, obtained increased mobility of the spine and extremities and relief from suffering. Their posture and gait improved. Because of these results in cases previously treated by numerous methods without success, we feel that the use of roentgen therapy is justified in certain cases of advanced rheumatoid arthritis.

The therapeutic results depend upon the action of the roentgen rays on the joint lesion and the periarticular tissues. We be-

TABLE I: ANALYSIS OF TEN CASES OF ARTHRITIS RECEIVING ROENTGEN THERAPY

Case	Age and Sex	Duration of Illness in Years	Previous Therapy	Roentgen Therapy: Joints Involved	Roentgen Therapy: Stage	Roentgen Therapy: No. of Roentgens in Air	Result of Roentgen Therapy
1. A. D.	29M	9	*Medical* Gold therapy (2 courses); numerous other drugs *Orthopedic* None *Physical* Heat; massage; exercises; whirlpool	Temporomandibulars Elbows Wrists Hips Knees Ankles Cervical spine Dorsal spine Sacro-iliacs	2 1 1 3 3 3 3 3 3	1,800 each 2,400 each 1,800 each 3,200 each 3,200 each 2,400 each 1,200 2,400 2,000	Pain decreased in all joint areas treated. Temporomandibular articulations free of pain and mobility returned to normal
2. M. W.	22M	7	*Medical* Gold and other drugs *Orthopedic* Vitellium cup arthroplasty, left hip *Physical* Heat; massage; exercises; whirlpool	Shoulders Hips Knees Cervical spine Lumbar spine Sacro-iliacs	1 3 2 3 3 3	2,400 each 3,800 each 3,200 each 1,200 2,200 2,200	Pain diminished. Improved mobility of cervical spine and knees. Mobility of shoulders returned to normal
3. J. G.	26M	14	*Medical* Sulfa drugs; autogenous and typhoid vaccines *Orthopedic* Traction and body cast *Physical* Heat; masage; exercises; whirlpool	Right hip Cervical spine Dorsal spine Sacro-iliacs	1 2 2 3	2,400 3,200 3,200 1,600	Pain decreased in areas treated. Mobility of right hip returned to normal. Resumed former occupation
4. F. W.	28M	14	*Medical* Gold; sulfa drugs; typhoid vaccines *Orthopedic* Cast for neck and body; crutches *Physical* Heat; massage; exercises; whirlpool	Shoulders Hips Right knee Left knee Ankles Feet Cervical spine Dorsal spine Sacro-iliacs	1 2 2 1 1 1 1 2 3	2,000 each 3,200 each 3,200 800 2,400 each 1,800 each 2,400 3,200 3,000	Pain decreased in areas treated. Mobility improved in most of the joints. Discarded crutches. Resumed former occupation
5. H. H.	35M	10	*Medical* Gold (2 courses); vitamin B; bee venom; aspirin daily *Orthopedic* Casts for knees *Physical* Heat; massage; exercises; whirlpool	Right shoulder Left shoulder Hips Knees Right hand Left hand	3 2 3 3 2 3	3,200 2,800 4,800 each 4,200 each 1,600 2,400	Pain decreased in areas treated. Increased mobility in some of the fingers
6. N. G.	31M	4	*Medical* Gold; ertron; hormones *Orthopedic* Spine brace and sacro-iliac belt *Physical* Heat; massage; exercises; whirlpool	Hips Cervical spine Dorsal spine Lumbar spine Sacro-iliacs	1 1 2 2 3	2,400 each 1,600 2,400 1,200 1,200	Pain decreased in areas treated. Chest expansion increased 1 1/2 inches. Resumed former occupation

lieve that two factors determine the outcome: the stage of the disease, and the dose delivered.

Decrease of pain and increase of motion are the two beneficial effects, but they are not invariably associated. The relationship between the two varies considerably in different joints. The duration of the disease, although of significance, has not proved of great importance. Some joints apparently deteriorate rapidly, others slowly. The stage of the disease in the joint under treatment is the essential factor.

The best results were obtained in stage *one* lesions, where active but not passive

TABLE I: ANALYSIS OF TEN CASES OF ARTHRITIS RECEIVING ROENTGEN THERAPY.—*Continued*

Case	Age and Sex	Duration of Illness in Years	Previous Therapy	Roentgen Therapy			Result of Roentgen Therapy
				Joints Involved	Stage	No. of Roentgens in Air	
7. E. L.	26F	7	*Medical* Gold and other drugs *Orthopedic* None *Physical* Heat; massage; exercises; whirlpool	Shoulders Elbows Wrists Hands Hips Cervical spine Lumbar spine Sacro-iliacs	2 2 2 1–3 1 2 3 3	3,600 each 3,200 each 3,200 each 2,600 each 3,200 2,000 2,400 2,400	Pain decreased in areas treated. Mobility increased in some. Works as a counter girl at a news stand
8. I. C.	23F	2	*Medical* Gold; typhoid vaccine; vitamins B and D *Orthopedic* None *Physical* Heat; massage; exercises; whirlpool	Elbows Hips Knees Ankles Cervical spine	2 1 1 1 2	3,200 each 1,500 each 3,200 each 1,800 each 3,200	Pain decreased in areas treated. Mobility increased. After 4 months, recurrence in a few of the treated areas, and progression in some of the non-treated areas
9. M. E.	37F	11	*Medical* Gold; fever therapy; many drugs *Orthopedic* Casts on both lower extremities *Physical* Heat; massage; exercises; whirlpool	Shoulders Elbows Knees Ankles Lumbar spine	2–3 2–3 2–3 2–3 2	3,200 each 3,200 each 4,800 each 1,800 each 1,200	Pain decreased for a few months; then returned
10. M. L.	45F	6	*Medica* Cobra venom; aspirin daily *Orthopedic* Neck cast; tenotomy of flexors of knees *Physical* Heat; massage; exercises; whirlpool	Right shoulder Hips Knees Hands Cervical spine Lumbar spine	3 2 2 1 2 2	3,200 4,800 each 2,400 each 1,200 each 2,400 2,400	Pain decreased in areas treated. Walking improved. Pain returned to spine after 2 months, and to right shoulder after 4 months

motion is limited. Here mobility is restricted because of spasm due to pain caused by the pathological process within the joint. With the elimination of pain, active mobility returned to normal. With relief of pain in *stage two*, increased mobility is in direct proportion to the amount of spasm and destruction within the joint. The increased active mobility is comparable to the extent of passive mobility. Another factor which plays a part is the transformation of granulomatous tissue into scar tissue within the joint. In *stage three*, because of the ankylosis, either fibrous or osseous, there is no return of mobility even with relief of pain.

Another beneficial effect is a decrease of the swelling; and on one occasion we observed a reparative process at the site of a destructive bone lesion.

COMMENT

It appears that doses varying considerably in amount are required to obtain comparable effects in joints in different stages of the disease process, even in the same individual. If, of the interphalangeal joints of three neighboring fingers one is in the first stage, another in the second stage, and the third in the third stage, a given dose of x-rays may be highly effective in the first, slightly effective in the second, and not at all effective in the third. The same holds true for different parts of the spine, depending upon the stage of the disease process. A given dose producing a favorable result in the cervical spine may be only moderately effective in the dorsal spine and fail to produce any effect in the lumbar spine, if the cervical spine is movable, the

dorsal spine moderately restricted in its motion, and the lumbar spine is ankylosed.

To obtain a comparable effect, larger doses of x-rays are required in the more advanced stages. The difference in dosage may be as much as 100 per cent. If 800 r eliminates pain in the first stage, 1,200 r may be necessary for the second stage, and 1,600 r for the third, in order to obtain comparable results. This is due to the fact that the pain in the three stages is due to different causes. Pain may be produced by edema in the early stages, by granulomatous tissue in later stages, and by scar tissue in the final stages. The effectiveness of roentgen rays depends upon the sensitivity of the tissues irradiated, which, in turn, depends upon their anatomical structure and biological activity. Dilatation of capillaries followed by increased resorption of inflammatory products can be obtained by a smaller dose than is necessary to cause regression of granulomatous tissue.

Granulomatous tissue requires different doses in its various stages. The earlier the stage in which it is treated, the smaller is the dose of x-rays required either to destroy or arrest its growth. In this respect, there is a far-reaching analogy between the radiation effect on the granulomatous tissue in rheumatoid arthritis, in Hodgkin's disease, in keloids, and benign giant-cell tumors. There is a similarity in the cellular composition of these tissues and, accordingly, in their response to roentgen rays.

We have treated a number of patients in part with smaller doses, and others with larger doses than indicated above. The small doses were found to be either not effective at all or for less than a year, often for only a few weeks or a few months. We have concluded that a joint in a late stage of rheumatoid arthritis should not be considered as adequately treated if the dose delivered to the lesion is less than 1,600 r within a period of four weeks. Larger doses, or the same dose delivered in less than two weeks, are apt to produce undesirable reactions, to be discussed later.

It is not unlikely that in the future it may be found necessary to increase or decrease the dosages given in this series. When the significance of the time factor in the roentgen treatment of rheumatoid arthritis is better understood, it may be found that the dose given in a single session should be larger and the intervals between single applications should be either decreased or increased, and the total dosage changed accordingly.

Radiation in effective dosages in the advanced stages of rheumatoid arthritis can produce undesirable effects in both the skin and the blood-forming tissues.

The largest depth dose delivered to a joint was 1,600 r in three to four weeks. This is only a fraction of the dose applied in cancer, which may require between 3,500 and 5,000 r to the tumor area in an equal period of time. In our experience skin reactions of undue intensity or of a permanent character occurred in a few cases in which a second course of irradiation was given before the skin had had time to recover from the first series. We believe that a second course of x-ray therapy should not be instituted in less than one year to a joint area which has previously received a dose of 1,600 r. Heavier filtration should be used during the second course.

When a single course of irradiation is given, as was the case with most of our patients, any skin reaction of undue intensity or of a permanent character can be avoided when the general rules concerning the application of roentgen rays are observed. In the majority of cases, erythema, pigmentation, and sometimes desquamation, varying in intensity according to the dose, are the only skin reactions encountered. All of these are of a temporary nature and none requires specific treatment.

Since the white and red blood cells are in part produced by different tissues, it is necessary to consider them separately in assessing the effects of radiation.

The lymphocytes are produced in the lymph nodes, which are present throughout the body. Consequently they are irradiated whenever any part of the body is

treated with roentgen rays. In the treatment of arthritis, however, the irradiation is limited to a single area, or at most to two areas at the same time, so that the effect of the rays is confined to a small group of nodes and remains, therefore, clinically unnoticed. Only with exposure of a large part of the body, or multiple areas, may a drop in the number of lymphocytes be found.

Since the red blood cells and certain of the leukocytes in adults are formed by the red marrow, a drop in their number can be expected when the hips, shoulders, intervertebral, or costovertebral joints are irradiated. From experience with roentgen therapy of cancer metastases we know that heavy irradiation of the vertebral column does not produce noteworthy changes in the blood picture when a part of the spine only is treated. It appears, therefore, that when the entire spinal column is affected by rheumatoid arthritis, as not infrequently happens, only one part should be treated at a time, and a period of rest should be given before the treatment of the next area is begun. When the spinal and the peripheral joints are affected, they should be treated alternately. Furthermore, the fields including the intervertebral or costovertebral joints may be long but should be narrow, to exclude as much of the ribs as possible from the field of irradiation.

It should be borne in mind that rheumatoid arthritis tends of itself to produce an anemia. This may be slight, or may assume larger proportions, in which case "it becomes more than a symptom and constitutes a complication" (Pemberton). An anemia may be induced, or an existing anemia aggravated, and the white count depressed, if treatment to multiple joint areas is too active and without interruption. When the blood count discloses an advanced stage of anemia, a blood transfusion should be given prior to or during the course of roentgen therapy. No drug with toxic effects, such as the sulfa drugs or gold preparations, should be given coincidentally with irradiation. When roentgen therapy has a beneficial effect on the disease process, the anemia improves and there is an associated decrease of the sedimentation rate.

Radiation therapy is a local and not a constitutional form of treatment and can be given to only one or a few joints at the same time. Since rheumatoid arthritis is a polyarthritic condition, it is obvious that agents which affect simultaneously all joints involved, such as gold, vitamins, or baths, are superior to x-rays. Therefore, roentgen therapy should never be applied as a primary method in rheumatoid arthritis, but should be reserved for cases which fail to respond to other therapeutic measures. Roentgen irradiation should be supplemented by physiotherapy, particularly exercises and massage.

Patients in generally poor health, with a progressive anemia, with advanced atrophy of the muscles, should not be subjected to x-ray therapy.

SUMMARY

During the past two years we have treated 66 patients with advanced rheumatoid arthritis, patients who failed to respond to the usually accepted methods of treatment such as gold therapy, vaccines, physiotherapy, surgery, etc. These patients were treated according to their pathological status as determined by clinical and roentgen examinations. The involvement was classified as stage one, two, or three, and the amount of radiation delivered depended upon the stage of the disease process within any given area. Of this group we selected for critical study 10 patients, with a total of 85 joint areas involved. Good results were obtained in most cases. Roentgen therapy is given for the relief of local symptoms, to alleviate pain, and increase mobility, and is employed only after failure of the usually accepted methods of treatment.

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Solitary Myeloma: Review of Sixty-one Cases[1]

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THE TREATMENT and prognosis of multiple myeloma are usually regarded as extremely discouraging. In recent years, however, numerous reports have appeared of solitary myeloma and in many of these cases x-ray therapy, judiciously carried out, delayed the progress of the disease, produced relief of symptoms, and prolonged life.

Among 24 cases of myeloma seen in the University of Chicago Clinics, 2 examples of solitary lesions have been observed, both of which responded excellently to x-ray therapy.

CASE REPORTS

CASE I: T. O., a machinist aged 48 years, was seen on May 14, 1941, complaining of persistent pain in the right hip, following an injury six months previously. The pain was dull, aching in nature, more severe on exercise, and accompanied by a slight limp. The history was otherwise irrelevant.

The patient was well nourished and robust, with tenderness in the right hip on all extremes of motion but no other abnormal physical findings. The red blood cell count was 4,700,000; hemoglobin 13.0 gm.; white cell count 8,000. The specific gravity of the urine was 1.028; it contained no albumin or sugar, no casts or red blood cells. No test was made initially for Bence-Jones protein. The Wassermann reaction was negative.

X-ray examination of the right hip disclosed a large multiloculated expansile lesion of reduced density involving the greater portion of the ilium adjacent to the acetabulum and of the ischium (Fig. 1). The margins of the lesion were sharply defined and the overlying cortex was irregularly thinned.

On May 21, 1941, a biopsy was performed. In the region about the spine of the ischium along the posterior wall, the bone was eroded by a soft, grayish-red tissue. This was curetted out. Microscopic examination showed densely packed round cells with dark, round, eccentrically placed nuclei at the periphery of which chromatin was distributed in cart-wheel pattern. A diagnosis of plasma-cell myeloma was made. The urine was then tested for the presence of Bence-Jones protein and none was found. Plasma proteins were 7.04 gm. per cent with A/G = 3.85/3.19 = 1.20.

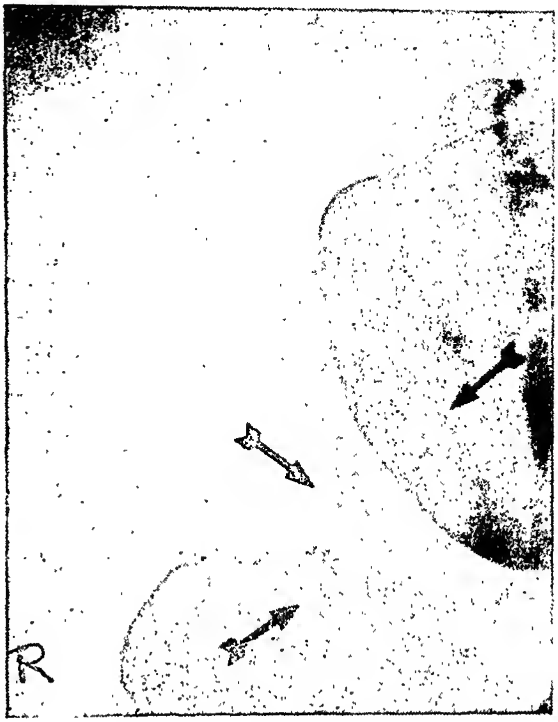

Fig. 1. Case I. Multiloculated lesion of right ilium adjacent to the acetabulum and of the ischium.

On June 7, 1941, x-ray therapy was begun. The patient received treatments of 300 r in air to each of three portals at 200 kv., 20 ma. A total of 2,500 r to each of three portals was given in three weeks. Following these treatments the patient experienced marked relief of pain and subsequently returned to work.

On Sept. 12, 1941, the patient was again seen, complaining of occasional pain in the right hip. The x-ray appearance of the lesion was unchanged. A second series of roentgen treatments was then given, for a total dose of 2,500 r to each of three portals.

From that time until Jan. 30, 1945, four years and three months after the onset of symptoms, there had been no progression of the disease as seen by x-ray examination. The only noteworthy change was progressive collapse and flattening of the head of the right femur due to necrosis produced by the radiation. Roentgenograms of the rest of the skeleton and the chest (Sept. 6, 1944) were negative. The patient still had some pain and difficulty in walking but had been able to continue with his work. A total depth dose of 5,200 r had been given.

[1] From the Department of Surgery, The University of Chicago. Accepted for publication in January 1945.

Fig. 2. Case II. Lesion of right ilium adjacent to the sacroiliac joint and extending along the crest.

CASE II: S. T., male aged 68 years, a physician, was admitted on Dec. 13, 1937, with pain in the right hip of four months' duration, gradually increasing in severity. The pain was dull and aching in nature. Except for the presence of diabetes mellitus, controlled by diet, the history was irrelevant.

The patient was well nourished and well developed, walking with an obvious limp. His general condition was unimpaired. A large mass was palpated in the right ilium, extending from the sacroiliac joint to the anterior portion of the bone. There was pain in the region of the right sacroiliac joint upon abduction and rotation of the right leg. The red blood cell count was 4,240,000; hemoglobin 8.52 gm., white cell count 6,900. The specific gravity of the urine was 1.024. It contained no albumin, no sugar, no red blood cells or casts. The Wassermann reaction was negative.

X-ray examination disclosed a large area of reduced density in the upper portion of the right ilium adjacent to the sacroiliac joint and extending along the crest as far as the anterior superior spine (Fig. 2). Coarse trabeculae of increased density were present within the lesion.

On Dec. 15, 1937, a biopsy was performed. At the crest of the ilium a dark reddish-brown mass had extensively eroded the bone. Microscopic examination disclosed large, closely packed oval cells with cartwheel granules and eccentric nuclei. The diagnosis of plasma-cell myeloma of the ilium was made. The urine was negative for Bence-Jones protein.

Previous to admission, the patient had received x-ray therapy, 1,500 r in air having been given to the right pelvis through each of two portals, totaling 3,000 r. Treatment was continued with doses of 300 r to each of two portals (220 kv., 50 cm. distance, Thoraeus No. 1 filter). In June 1938, ten months after the onset of symptoms, a total of 13,000 r had been given. At this time the patient's condition was excellent, x-ray examination showed no further extension of the lesion, and some recalcification had taken place at the margins.

The patient was again seen on Nov. 18, 1938, at which time the pain had increased somewhat. The lesion appeared unchanged. X-ray therapy was continued. The condition then remained unchanged until Nov. 21, 1941, when the patient was found to have a carcinoma of the prostate, from which he died in July 1942. He had lived four years and eleven months from the onset of symptoms referable to the myeloma, during which time over 28,000 r had been applied to the right hip. At no time was generalization found.

These cases, together with 59 similar cases of solitary myeloma collected from the literature, were studied with regard to the duration of life, the effects of x-ray treatment, and the course of the disease as compared to that of multiple myeloma. The diagnosis in all of these cases had been confirmed by biopsy and histologic examination. Geschickter and Copeland in 1931 collected 5 cases reported up to that time. In 1936 Cutler, Buschke, and Cantril reviewed 18 cases collected from various sources. Paul and Pohle in 1940 submitted a series of cases collected from the literature, including 5 coming under their personal observation. Additional examples have been reported by King, Abel, Toth and Wintermantel, Coley, Bichel and Kirketerp, Willis, Esposito, and Batts.

CLINICAL OBSERVATIONS

The average age of the 61 patients in this series was fifty years. Only two were under thirty; one was seventy-one. The distribution by decades was as follows:

Below 30 years	2 (3%)
30 to 40 years	10 (16%)
40 to 50 years	12 (19%)
50 to 60 years	26 (44%)
60 to 70 years	10 (16%)
Over 70 years	1 (2%)

Forty-one patients, or 68 per cent, were males; 20, or 32 per cent, females. The same high incidence in males and predominance in the fifty-to-sixty-year age group is characteristic of multiple myeloma. Batts reported 40 cases of multiple myeloma, of which 63 per cent were in males. Similarly, Geschickter and Copeland recorded a series of cases of multiple myeloma with the peak of incidence at fifty-five years, with 70 per cent of the patients males.

The most frequent site of involvement is the ilium, followed by the femur, humerus, and thoracic vertebrae. The figures for the series are as follows:

Site	No. of Cases
Ilium	13
Femur	9
Humerus	9
Thoracic vertebrae	9
Skull	5
Cervical vertebrae	4
Lumbar vertebrae	3
Maxilla	3
Clavicle	1
Scapula	1
Sternum	1
Tibia	1
Pubis	1
Sacrum	1
TOTAL	61

It is of interest that the ribs, which are a frequent site of multiple myeloma, were not involved initially.

In 41 cases tests were made for Bence-Jones protein in the urine. In only 4 instances was it found early in the course of the disease. It appeared as a late manifestation in 9 cases, in 7 of which generalized spread of the lesions had occurred. The small number of early cases showing Bence-Jones protein—4 out of 41, or 10 per cent—is in contrast to the usual finding in multiple myeloma. Batts reported Bence-Jones protein present in 50 per cent of 40 cases, while Geschickter and Copeland reported its presence in 65 per cent of their collected series of multiple myeloma.

Clinically the outstanding complaint on first admission is of pain. This is usually fairly well localized to the area of the lesion, aching in nature, chronic, and gradually increasing in severity. A mass may be palpable and tender. Pathological fracture is frequent, especially following exertion, a fall, or undue stress and strain. The patient frequently gives a history of injury or of a fall months previously.

The generalized weakness and anemia of multiple myeloma are rarely found in these cases. Hyperproteinemia and renal damage with accompanying nitrogen retention, low blood pressure, albuminuria, and urinary casts, seen so commonly in multiple myeloma, are seldom encountered in cases of solitary myeloma.

ROENTGEN APPEARANCE

The roentgenologic appearance is of great importance in the diagnosis of solitary myeloma. Differentiation from other similarly destructive lesions of bone may be difficult, and biopsy should be done in all cases.

Two types of lesions have been described roentgenologically. The first type is cystic and trabeculated, closely resembling giant-cell tumor. The lesion is large, of reduced density, and sharply limited, and within it are thickened irregular trabeculae. It is usually found in the pelvis or long bones, in the medullary portion of the bone, frequently expanding the cortex. Pathological fracture is often present. The second type of lesion as observed roentgenologically is purely destructive, very similar in appearance to an osteolytic cancer metastasis. It is sharply demarcated, homogeneously rarefied in appearance, and seldom shows expansion. The vertebrae are frequently involved. The histologic appearance of the two types of lesion is the same.

Solitary myelomas are frequently confused with giant-cell tumors. In this connection Paul and Pohle say: "Given a cystic trabeculated lesion, expansile in character . . . . in an atypical place for giant-cell tumor, myeloma should be considered." Other lesions entering into the differential diagnosis are solitary bone cyst, carcinoma metastasis, and osteolytic types of sarcoma.

PATHOLOGY

In 57 of the cases of this series the histologic diagnosis was plasma-cell myeloma; the cell type was not stated in the remaining 4 cases. The typical pathological picture is that of densely packed, large irregular cells, round or oval, measuring 9 to 11 μ. There is little evidence of stroma. The nuclei are eccentrically placed, dark-staining, with chromatin granules in cart-wheel pattern at the periphery.

TREATMENT

Various forms of surgery and irradiation, either alone or combined, have been used. Irradiation has been given in the form of deep x-ray therapy, surface radium, interstitial radium, or radon seeds. Surgical procedures have included curettage, partial resection, complete resection, and amputation.

Forty-three cases were treated by irradiation following biopsy or curettage. In many cases irradiation was continued over several years. The dosage varied with different authors but treatments were usually given in fractions of from 200 to 500 r to each of two or more portals in courses totaling 1,000 to 3,000 r. By preserving skin surfaces and using as many portals as feasible, it is possible to give large total doses.

Batts, treating a myeloma involving the ilium, used an initial dose of 300 r in air delivered through each of three 20 × 20-cm. portals. This relieved pain and the patient was able to resume walking. Subsequent treatments were given once a month for five months, with 200 r in air per portal. One year later this series was repeated. At that time there was evidence of generalization and treatments were given to dorsal and lumbar vertebrae, ribs, and femur in the same manner. They were carried out at varying intervals for the following eight years with continued relief of pain. The patient lived over fourteen years from the onset of symptoms and over nine years after treatment was begun.

Esposito treated a myeloma of the frontal bone with 4,100 r in air over a period of sixteen days. Toth and Wintermantel gave their patient 1,700 r/skin through each of three portals in a total of fifteen sessions. Remission of pain was noted. Four months later the treatments were repeated and improvement continued.

In the case reported by Pohle and Stovall and later reviewed by Paul and Pohle, deep x-ray therapy was given in repeated doses of 200 r to each of two portals. Subsequently, as the condition became generalized, "general body exposure" was employed, 25 r being administered to each of four fields to include the entire body surface. Paul and Pohle report good results with the latter technic in some instances.

The two cases reported in the present paper were treated with 300 r in air to two or more portals with a total dosage of 2,500 r per portal for each course. This was repeated in one patient several times, and marked symptomatic improvement was obtained.

EFFECTS OF TREATMENT

It is instructive to compare the duration of life in treated cases of solitary myeloma with that in multiple myeloma. Geschickter and Copeland give the average duration of multiple myeloma as two years. Batts found the average duration from the onset of symptoms until death to be two and one-half years.

Of the 43 patients with solitary myeloma in our collected series treated by irradiation following biopsy or curettage, 27 were alive at the time of the report and 16 were dead. One death occurred shortly after operation from cardiac failure; of the remaining 15 who had died, all but one lived over two and one-half years from the onset of symptoms. The average duration of life from the onset of symptoms was seven years. Eight patients lived over five years. Twelve of the 15 patients lived over two years from the original admission, 9 of these over three years, and 5 over four years. The average duration of life from the time of the original admission was three years and nine months as compared to the aforementioned figure of fourteen months for multiple myeloma (see Table

TABLE I: DURATION OF LIFE IN 43 CASES OF SOLITARY MYELOMA TREATED BY IRRADIATION

	1 yr.	2 yr.	3–5 yr.	5–7 yr.	7–9 yr.	Over 9 yr.
Sixteen patients dead at time of report*						
Duration from onset of symptoms: average 7 yr.						
No. living *to* each period	..	2	5	4	1	3
No. living *in* each period	15	15	13	8	4	3
Duration from first admission; average 3 yr. 9 mo.						
No. living *to* each period	1	3	6	1	1	1
No. living *in* each period	13	12	9	3	2	1
Twenty-seven patients living at time of report						
Duration from onset of symptoms: average 3 yr. 8 mo.						
No. living *to* each period	6	4	2	6	3	1
No. living *in* each period	22	16	12	10	4	1
Duration from first admission: average 3 yr.						
No. living *to* each period	6	2	4	4	2	1
No. living *in* each period	19	13	11	7	3	1

* One death postoperatively from cardiac failure.

I). The true average may be still higher, as only 9 of the patients died of generalization; the remaining 7 succumbed to other causes.

Of the 27 patients who were living at the time of report, many had not been observed long enough to warrant definite conclusions as to duration of life. Twenty-two, however, were alive over one year from the onset of symptoms; 16 were alive over two years. Nineteen of the 27 patients were alive over one year after admission and, of this number, 13 were alive over two years.

Of the 43 patients treated by irradiation—discounting the one postoperative death—all but 2 obtained relief of pain and many returned to normal activity. In 29 cases recalcification of the lesion demonstrable by x-ray was reported.

Generalized spread took place in 14 of the 43 cases and accounted for 9 of the 16 deaths, the average time elapsing between admission and generalization being twenty-one months. Of the 9 patients dying from generalization, 5 lived over two years with multiple foci which were treated by irradiation. Five patients were living with generalized lesions at the time the cases were reported.

There can be little doubt of the value of x-ray therapy in the treatment of solitary myeloma. Though irradiation assuredly does not cure the disease, persistent and intensive treatment of the original lesion and of recurrences definitely delays generalization and, even when this has occurred, produces symptomatic relief. Needless to say, such a program of treatment necessitates frequent x-ray examination in order that recurrences and new foci be detected early.

RELATION OF SOLITARY MYELOMA TO MULTIPLE MYELOMA

Cutler *et al.* are of the opinion that there are two types of solitary myeloma, one type in which the lesion is solitary in the beginning and later becomes generalized and a second type in which the lesion is completely benign in nature, remaining localized throughout its entire course.

As suggested by Paul and Pohle, the evidence appears to indicate that myeloma may show varying degrees of malignancy from the rapidly progressing multiple form to the solitary lesion which may remain localized for as long as eight or ten years without generalization. Such solitary myelomas may be considered to be at the "benign" end of a gradient, while the widely spreading, rapidly fatal multiple form is at the opposite "highly malignant" end. Between these two extremes there will be found intermediate types, such as multiple myelomas of longer duration and solitary myelomas of more rapid spread and less radiosensitivity. The wide variation

in the duration of the disease, in the time elapsing before generalization, and in the radiosensitivity of both multiple and solitary myelomas strongly suggest such an explanation.

It is possible, as Paul and Pohle state, that cases of multiple myeloma with symptoms of long duration, if seen early enough, would present a solitary lesion which would respond well to x-ray therapy. In many instances it appears reasonable to suggest that the multiple form of myeloma is multiple at the time of first observation because spread occurred early from a primary focus and only with generalization did the typical appearance of multiple myeloma become manifest.

The evidence indicates that the cyst-like trabeculated lesion seen by x-ray is more benign and more amenable to roentgen therapy, and that in those cases where generalization occurs early the more osteolytic type of lesion is predominant.

As to the nature of myeloma, whether its etiology be that of a blood dyscrasia or a true neoplasm, the evidence from these cases is not conclusive. The type of generalization is suggestive of true neoplasia, yet Bichel and Kirketerp in two reported cases of solitary myeloma found a high proportion of plasma cells by sternal puncture.

SUMMARY AND CONCLUSIONS

1. Fifty-nine cases of solitary myeloma are reviewed and 2 new cases added. In every instance the diagnosis was confirmed by biopsy.

2. The x-ray appearance is of two main types. One type appears as a cystic, trabeculated lesion closely resembling giant-cell tumor. The second is a frankly osteolytic lesion closely resembling metastatic carcinoma.

3. The incidence of the disease was highest in the fifty-to-sixty-year age group, in which 26 cases, or 44 per cent, were found. Males were predominantly affected, accounting for 41 cases, or 68 per cent. The ilium, femur, humerus, and thoracic vertebrae were the sites most frequently involved. Bence-Jones protein was found initially in only 10 per cent of the 41 cases tested.

4. X-ray therapy following biopsy or curettage was carried out in 43 cases and appears to be the treatment of choice. It gave relief of pain and prolonged life several years beyond the average for multiple myeloma.

5. The average duration of life in the treated cases followed until death was seven years from the onset of symptoms and three years and a half from the original admission.

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Volvulus of Megacolon Reduced During Barium Enema Examination[1]

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VOLVULUS of a megacolon probably occurs more frequently than is generally appreciated. Weeks (1) reported an example and reviewed some 63 cases which he gathered from the literature. Half of these patients had previously experienced attacks of obstipation, abdominal pain, and distention. It is not unreasonable to assume that volvulus, either partial or complete, occurs not infrequently in patients with megacolon and can be reduced before strangulation or necrosis ensues. Report of a case of megacolon complicated by volvulus in the sigmoid region and reduced during barium enema examination follows:

CASE REPORT

A. M., a white male aged 39, entered Mount Sinai Hospital on Jan. 12, 1944, complaining of abdominal cramps which had been increasing in severity for two weeks prior to entrance. The patient stated that he was "normally constipated," but that constipation had been more troublesome in the past two months. Only mucus and very little fecal matter, the latter in the form of small hard nodules, were passed at intervals of several days. No blood was observed in the stool, but tenesmus was present. The abdomen had become increasingly distended during the last few months. The appetite was fairly good but the patient complained of some nausea several days before entering the hospital. The family history was essentially negative.

The patient was well developed and well nourished, and subacutely ill. The temperature was 98° F., pulse 104, respirations 20, blood pressure 124/76. Examination of the head, neck, and chest was essentially negative. The abdomen was moderately distended and tympanitic throughout. No masses were palpable and no definite abdominal tenderness was present. The bowel sounds were diminished in intensity but slightly increased in number. The clinical impression was "acute mechanical obstruction of the distal colon, cause undetermined but carcinoma to be excluded."

Blood determinations on admission to the hospital showed 14.5 gm. of hemoglobin and a white cell count of 7,850, the differential count being normal. Urinalysis was essentially negative; only a few leukocytes were demonstrated per high power field. The blood Kline test was negative.

Fig. 1. Anteroposterior roentgenogram of abdomen taken on day of admission, Jan. 12, 1944, showing distention of the large intestine down to about the sigmoid colon. Roentgen appearance consistent with diagnosis of mechanical intestinal obstruction.

Roentgen examination of the abdomen in the recumbent and upright positions on the day of admission to the hospital showed great distention of the large intestine apparently down to about the level of the distal descending or sigmoid colon. The right half of the colon contained a considerable amount of fecal material. Marked dilatation and elongation of the overlapping distended loops of large bowel were observed (Fig. 1). A few loops of small intestine were seen to contain small quantities of gas, irregularly distributed. In the upper abdomen a few fluid levels were demonstrated, but there was no evidence of free gas in the peritoneal cavity. The roentgen appearance of the abdomen was consistent with a diagnosis of mechanical obstruction in the distal colon, probably distal descending or sigmoid. There was no evidence of a

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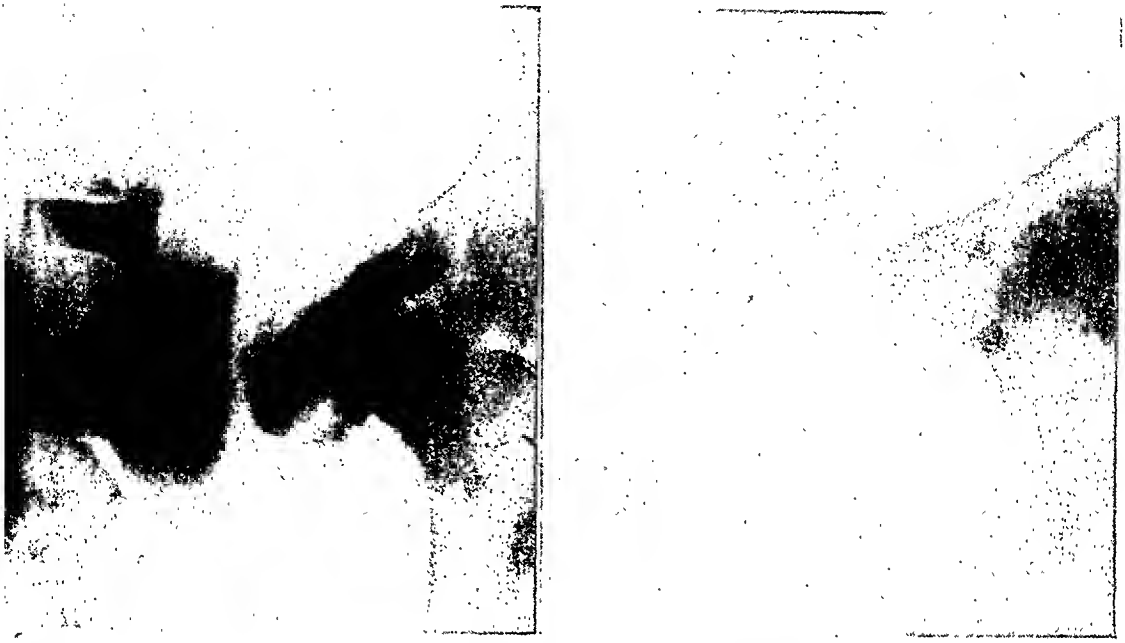
[1] From the Department of Radiology, Mount Sinai Hospital, Milwaukee, Wis. Accepted for publication in January 1945.



Figs. 2 and 3. Spot roentgenograms made during barium enema examination, Jan. 13, 1944. The view on ıe left shows almost complete obstruction in the elongated sigmoid flexure. Twisting is demonstrated by the ›iral mucosal pattern at the site of obstruction. The right-hand view, made shortly afterward, shows the procss of untwisting, relieving the obstruction.

ıptured abdominal viscus. Barium enema exmination was advised.

Barium enema examination performed the next ay, Jan. 13, 1944, revealed almost complete obruction in the sigmoid region (Fig. 2). The mu›sal pattern indicated rotation or twisting of the ırge bowel in this region. As more opaque subıance was carefully and slowly injected, untwisting ccurred (Fig. 3) and the obstruction was gradually ːlieved and reduced. Filling of the entire colon ıen became possible, but one and a half to two galıns of barium sulfate were necessary for this, ıdicating the presence of megacolon. No other ʼidence of obstruction was demonstrated and there ʼas no evidence of either a neoplastic or infiltrative ːsion.

Re-examination of the colon on Jan. 14, 1944, two ays after admission to the hospital, showed no evience of obstruction or volvulus. Great dilatation nd elongation of the entire colon were again oberved (Fig. 4), but the dilatation was most conpicuous in the sigmoid region.

Clinical improvement followed the barium enema xamination and the abdominal distention and ympany disappeared. The patient was dismissed hree days after admission and has been in good ondition ever since.

Fig. 4. Right anterior oblique roentgenogram after injection of 1 1/2 to 2 gallons of barium sulfate mixture. No signs of obstruction are present.

COMMENT

Megacolon or Hirschsprung's disease, in ontradistinction to volvulus, occurs most requently in the young. Johnson and Benson (2), in their discussion of the surgical treatment of megacolon, state that the acquired form is always secondary to an obstructive lesion. Congenital cases, however, may or may not be due to obstruction. It is claimed that the sigmoid is the

favorite site and that the rectum is involved in only one-third of the cases.

Grimson and his colleagues (3) believe that the prognosis depends upon the pathologic type of the disease. On this basis they classify patients with megacolon in three groups. Of the 24 cases in their series, 12 belonged in the first group, with immense dilatation of the entire colon plus definite dilatation of the rectum. Group 2, with severe dilatation of the colon down to the sigmoid and a normal rectum, included 7 cases. The prognosis in this group is poor. In the third group, accounting for the remaining 5 patients in the series, there is enlargement of the descending and sigmoid segments with or without involvement of the rectum and proximal colon. It is beyond the scope of this paper and the experience of the author to discuss the basic etiologic factors of megacolon. The reader is referred to Bockus (4), who considers the etiology under three headings: mechanical causes, inflammatory causes, deranged nervous mechanism.

Volvulus, the twisting of a portion of bowel about the axis of its mesentery, probably occurs with equal frequency in the sigmoid and ileum. Some statistics favor the sigmoid as the more common site; others the ileum. Increased length of the bowel and shortening of the mesenteric attachment are necessary for the development of volvulus. It occurs two to four times as frequently in the male as in the female, while for Hirschsprung's disease the corresponding ratio is 3 to 2. Volvulus is responsible for approximately 10 per cent of cases of mechanical intestinal obstruction and is more frequently seen after middle life. Weeks (1) discovered that only 13 per cent of the cases occur under the age of twenty. Some observers believe there is a greater tendency for volvulus to develop in Russians and Serbians. Whether anatomical factors, dietary habits, or both, are responsible for this apparent racial difference is difficult to explain. In the series reported by Grimson *et al.* (3), described above, there were 2 cases of volvulus in the first group.

The pathology of megacolon and vol vulus is well presented and discussed b Bockus (4) and Martin and Ward (5). I the acquired and congenital forms of mega colon the muscular layers are hypertro phied. In the congenital forms, the my enteric plexus is atrophied, but there i some disagreement as to its status in th acquired cases. Some authorities say tha it is atrophied while others believe that it i normal. Necrosis is not necessarily a accompaniment, or result, of volvulu Fortunately there is a multiple blood sup ply, which probably prevents segmenta necrosis in many instances. Superimpose infection in cases of complete rotation i probably the determining and aggravatin factor in the production of necrosis. Sta tistics with reference to the direction c twist in volvulus are not complete, bu Weeks (1) mentions that of 21 cases in th literature in which note was made of thi feature, 15 showed clockwise and 6 counte clockwise rotation.

Weeks (1) emphasizes that the develop ment of volvulus should be suspected whe obstipation, abdominal distention, an acute abdominal pain occur in patient with megacolon. The symptoms of Hirsch sprung's disease are ordinarily chroni and irregular. Constipation is alway present, and the diarrhea often describe is one of overflow. Tenesmus is frequentl present. Attacks of volvulus give rise t thickening of the mesentery with subse quent shortening, and as the colon become increasingly elongated, the attacks becom more frequent. With their repetition, th chances of reducibility decrease and th possibility of subsequent segmental ne crosis becomes greater. The presence o fecal retention and impaction in a dilated colon which becomes obstructed or twisted predisposes to gangrene of the bowel as a result of secondary infection.

The clinical manifestations of volvulus will vary somewhat depending on the loca tion of the obstruction. The sigmoid and ileum are the usual sites. Recently a case of volvulus of the transverse colon was reported by Martin and Ward (5). Physical

examination should reveal all the signs of mechanical intestinal obstruction.

A complete roentgen study of the abdomen for intestinal obstruction should include anteroposterior and postero-anterior studies in both the recumbent and erect positions, though this technic must sometimes be modified if the patient's condition does not permit of examination in the erect position. In such an event, recumbent anteroposterior or postero-anterior projections with the patient lying on either side can be substituted. Enemata should not be administered prior to original x-ray studies, as they cause confusing gas shadows and often make it impossible for one to render a definite diagnostic statement or differentiate between paralytic ileus and mechanical obstruction. Roentgen diagnostic methods enable one to localize the site of obstruction in the great majority of cases. Precise localization is possible by means of a barium enema. To be able to demonstrate the actual twisting of the mucosal pattern, as we did in our case of volvulus, is probably a matter of chance, depending mostly on the degree of rotation. In acquired cases of megacolon one should attempt to demonstrate the primary cause or organic lesion, such as atresia, an inflammatory lesion, or neoplastic condition.

The treatment of volvulus of megacolon is at best unsatisfactory and discouraging. The colon is usually filled with feces and the patients are often debilitated. Superimposed infection causes, or is responsible for, strangulation and segmental necrosis and accounts for the poor surgical results. As strangulation of the bowel carries a high mortality, regardless of the type of treatment, proper therapeutic measures should be instituted in the management of patients with megacolon to prevent the occurrence of volvulus. Experience gained in a single case does not qualify one to make recommendations, but a carefully administered enema before gangrene has set in might actually reduce the twisting, with subsequent recovery from the acute mechanical obstruction. Such a column of fluid evidently exerts an untwisting force, so to speak. Surely no harm can be done if the procedure is carried out with due precaution, as in cases of intussusception.

SUMMARY AND CONCLUSIONS

A case of mechanical intestinal obstruction due to volvulus of a sigmoid megacolon, reduced by a barium enema, is presented. The literature on the subject is briefly discussed and the probable frequency of volvulus in megacolon is stressed.

If the possibility of reducing a volvulus of megacolon by a conservative measure exists, as shown by our example, then one is justified in recommending the early and judicious administration of enemata in patients with megacolon who experience episodes of acute abdominal pain, distention, and obstipation.

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EDITORIAL

The Endocrine Glands and Cancer

Patients with advanced malignant growths should be, and in most cases are, treated palliatively with roentgen rays or radium. The alleviation of symptoms when these agents are properly employed, in appropriate dosage, is too well known to require comment, yet it is striking how often we see what is considered a cancerocidal dose administered to a hopelessly incurable patient. We must, unfortunately, consider three out of every four cases referred to us as incurable. In most instances it is obvious which patients have early and sufficiently localized lesions to receive cancerocidal quantities of radiation. In such cases even a severe reaction is a small price to pay for eradication of the neoplasm. In the hopeless cases, however, the radiation reactions are without such compensation and are frequently so severe that the patient suffers more from the treatment than from the disease.

This is well exemplified in the treatment of prostatic cancer, either with platinum radium needles or radon seeds, when the implantation must of necessity be performed blindly, without knowing the extent or size of the prostate gland. The same may be said of external radiation as a supplementary agent or alone, when given in large quantities. The pain and dysuria resulting from such measures are indeed excruciating, and many times treatment has hastened death.

Fortunately, the studies of Huggins and Hodges on the treatment of cancer of the prostate by orchiectomy and by injections of estrogen have ushered in a new therapeutic era. Now, five years following the appearance of their first report, this method represents an outstanding addition to the armamentarium of the treatment of cancer, not as a curative measure but as a palliative procedure that can bring about complete relief of symptoms for months or even years. In many cases metastatic bone deposits have disappeared; metastases which were not demonstrable in the roentgenogram prior to treatment have become visible by changing from osteolytic to osteoblastic lesions.

The radiation therapist may in some cases bring about similar results in premenopausal patients with metastasizing carcinoma of the breast, by giving a castration dose to the ovaries. Premenopausal metastases in bone from carcinoma of the breast are invariably osteolytic, but not infrequently they may become osteoblastic following castration. The percentage of women who obtain relief by this roentgen procedure is not high, but when favorable results are obtained, they are striking and very much worth while in younger women. There is no evidence to indicate that castration of the young woman is advisable as a routine measure following operation. It is, therefore, better to reserve this procedure for those cases with known metastatic involvement. It is difficult to foretell, prior to castration, which patient will obtain relief, but it has been noted (Sosman) that palliation is more likely in women with bony metastases who have increased pain and tenderness before and during the menstrual period than in those not similarly affected.

The glands of internal secretion are thus seen to have a direct bearing on cancer, and the employment of proper measures dictated by this relationship may prolong life and alleviate suffering from incurable cancer.

HUGH F. HARE, M.D.

Radiological Society of North America
The Thirty-First Annual Meeting

At the time of the 1944 Joint Meeting of the Radiological Society of North America with the American Roentgen Ray Society, the decision was made to formulate plans for the Annual Meeting of the Radiological Society in 1945, in spite of the undercurrent of feeling that transportation problems and crowded housing facilities might make this extremely difficult or even impossible.

Tentative arrangements for holding the meeting in Cleveland were made by the Board of Directors and the Program Committee, enlarged by the appointment of several additional members located geographically. The interest and effort of this rather large committee are attested by the program appearing on the following pages. Because of the widespread feeling that a meeting might not be held and the fact that all physicians have been extremely busy, the number of papers listed is comparatively small. We feel that there will be general agreement, however, after reading the following titles and abstracts, that those papers obtained are well worth while. These contributions will be published in RADIOLOGY.

In lieu of the regular meeting and in conformance with the Constitution and By-Laws, the Board of Directors has arranged for a "token" meeting, which will be held, with business sessions and reading of the program by title, at the Drake Hotel, Chicago, Nov. 9 and 10.

To those who have contributed to the program I wish to express the sincere appreciation of the Program Committee and our regret that your papers may not be presented in the customary fashion. I am indeed sorry that it is impossible to hold our regular Annual Meeting.

LEWIS G. ALLEN, M.D.
President

THIRTY-FIRST ANNUAL MEETING, CHICAGO, NOV. 9–10, 1945

SCIENTIFIC PROGRAM

To Be Presented by Title

DIAGNOSTIC SECTION

The Early Diagnosis of Carcinoma of the Lung. GJERT M. KELBY, M.D., Minneapolis, Minn., AND LEO J. RIGLER, M.D., Professor of Radiology, University of Minnesota.

Abstract: Although Westermark described the emphysema of the lung which may occur early in the course of a bronchogenic carcinoma some years ago, this sign has not been freely utilized in the attempt to diagnose tumors of the bronchus at an early stage. In some cases of carcinoma of the bronchus it is possible to demonstrate an obstructive emphysema of one lung, similar to that found with foreign bodies, and this may be one of the earliest signs of a tumor which has as yet incompletely obstructed the bronchus. Three cases are reported to demonstrate this finding. Rapid changes in the appearance of the lung may occur so that within a few weeks after the demonstration of emphysema the characteristic atelectasis of an obstructing bronchogenic tumor may eventuate. The early type of atelectatic change simulating pneumonia is described. It is possible by routine fluoroscopic examination, with particular attention to the expiratory phase, occasionally to demonstrate tumors of the bronchus which are almost symptomless.

Spondylolisthesis and Prespondylolisthesis: Their Frequent Occurrence in the Absence of Symptoms. WILBUR BAILEY, M.D., Assistant Clinical Professor of Radiology, University of Southern California, AND RICHARD R. HALL, M.D., Los Angeles, Calif.

Abstract: The presence of a defect in the isthmus or pars interarticularis of one of the lower lumbar vertebrae is usually first discovered after the patient has a history of injury or low-back pain. Examinations of over 1,000 young men, none of whom had such complaints, showed a surprisingly large number of these defects. The evidence would, therefore, indicate that such lesions are congenital rather than traumatic in origin.

Retrograde Abdominal Aortography: A Contribution to the Study of the Abdominal Aorta and Iliac Arteries. PEDRO FARIÑAS, M.D., Habana, Cuba.

Abstract: The pathology of the abdominal aorta has received little attention from clinicians due to the fact that there was no practical method for its exploration. With retrograde abdominal aortography for study of the abdominal aorta and iliac arteries, the technic is reduced to that of simple arteriography. That pathological changes of the aorta and its branches can be clearly visualized and studied is demonstrated.

The Recognition and Management of Congenital Atresia of the Esophagus. JOHN F. HOLT, M.D., CAMERON HAIGHT, M.D., Associate Professor of Surgery, AND FRED JENNER HODGES, M.D., Professor of Roentgenology, University of Michigan.

Abstract: On the basis of experience gained in the handling of some 50 infants born with congenital malformations of the esophagus associated with atresia, the importance of x-ray methods of examination is discussed and hints regarding useful diagnostic procedures are presented. Surgical procedures often successful in the re-establishment of esophageal continuity are described and illustrated with results which have been obtained in several instances. Infants born with major abnormalities of the esophagus present diagnostic problems which are of particular radiologic concern, and the ultimate fate of these children depends to a considerable extent upon close co-operation between radiologist and thoracic surgeon.

Small Intestinal Dysfunction Associated with Peripheral Nerve Disorders. FRED JENNER HODGES, M.D., Professor of Roentgenology, University of Michigan, AND R. WAYNE RUNDLES, M.D., Ann Arbor, Mich.

Abstract: The combined clinical and roentgenologic study of 150 patients presenting clinical evidences of peripheral neuropathy associated with various diseases shows a surprising correlation between x-ray-demonstrable dysfunction of the small intestine and the more commonly observed evidences of peripheral nerve disorders. Of particular interest is the frequency with which profound abnormalities of small bowel behavior can be demonstrated in patients with uncontrolled diabetes, a situation which to date has received little attention. The case material from which these observations are derived includes, in addition to the diabetic group, pernicious anemia, lead poisoning, vitamin B deficiency, inflammatory diseases of the intestinal tract, toxic polyneuritis, tabes dorsalis, and other conditions in which peripheral neuropathy is a feature. Small bowel function has been studied as well in a group of normal subjects and in persons before and

after splanchnic resection and before and after total gastric resection.

Sequelae of Injuries to the Urinary Tract: Roentgenological Considerations. ARTHUR P. ECHTERNACHT, Indianapolis, Ind.

Abstract: During the preparation of a previous paper on the roentgenologic considerations of injuries to the urinary tract, the author became intrigued by the following question: What permanent changes, if any, occur in the anatomical configuration of the kidneys, ureters, and bladder and in the excretory function of the kidneys following injuries to the urinary tract that have been treated conservatively? A review of the literature reveals a scarcity of information about this subject from the roentgenological aspect. The author reports the results of his investigations.

A New Roentgen Sign in Extra-Biliary Tract Diseases. SAMUEL BROWN, M.D., Assistant Professor of Radiology, University of Cincinnati, AND FOREST G. HARPER, M.D., Cincinnati, Ohio.

Abstract: The basis of the new roentgen sign in extra-biliary tract diseases depends upon the intimate anatomical relationship which exists between the duodenum and neighboring structures. The neck of the gallbladder, the cystic and the common ducts form a tubular ring which almost completely encircles the superior flexure of the duodenum, the freedom of mobility of which is limited by the liver above, the pancreas below, and the right kidney behind. When any part of the tubular system is dilated because of obstruction due to a stone or tumor or by an extrinsic mass, the superior flexure of the duodenum frequently suffers compression of its contour. Since the proximal portion of the duodenum is directed from before backward, the pressure defect is demonstrable roentgenologically only in the right lateral decubitus position. This sign has enabled us to diagnose diseases of the gallbladder, ducts, liver, and pancreas which could not be diagnosed by usual x-ray methods. It has also enabled us to differentiate between obstructive and non-obstructive jaundice, being present in the former condition but absent in the latter.

Several representative cases have been chosen for a more or less detailed discussion illustrating the value of this roentgen sign.

Amebic Infections of the Colon as Seen in an Army General Hospital. LT. COL. JOSEPH C. BELL, M.C., A.U.S.

Abstract: A review of the characteristic findings in this condition and discussion of the morphologic changes responsible for the abnormalities that may be shown by the roentgen ray. Case histories and roentgen ray findings of illustrative cases are presented.

Significance of the Sacroiliac Findings in Marie-Strümpell's Spondylitis. JONAS BORAK, M.D., New York City.

Abstract: Anatomical, pathological, radiological, clinical, and therapeutic considerations lead to the conclusion that the sacroiliac findings in Marie-Strümpell's spondylitis are merely a reaction of the sacroiliac bones to the immobilization of the lumbar spine resulting from the pathological process taking place in the small intervertebral joints. The sacroiliac reaction is unspecific. It occurs not only in Marie-Strümpell's spondylitis but also in many other conditions restricting the mobility of the lumbar spine. It also occurs in a number of conditions causing a limitation of mobility of the hips.

The first manifestation of Marie-Strümpell's spondylitis is found not in the sacroiliac region but in the area between the eleventh dorsal and second lumbar vertebra, most frequently between the twelfth dorsal and first lumbar. From the radiological point of view, there is first a pre-radiological phase, in which only clinical symptoms are present. It is followed by a spondylitic or pre-sacroiliac phase, in which certain radiological signs are found in the spine while the sacroiliac joints are not affected. From its first localization in the lower dorsal and upper lumbar spine the disease spreads in the ascending direction along the dorsal spine and in the descending direction along the lumbar spine. When the larger part of the lumbar spine is affected and, as a result, immobilized for a prolonged period of time, the sacroiliac reaction becomes apparent and the sacroiliac phase of the disease begins.

A Duodenal Mechanism Regulating the Motor and Secretory Activity of the Stomach: Its Disturbance in Duodenal Ulcer. LT. COMDR. JACOB GERSHON-COHEN (MC) USNR.

Abstract: This report is a summary of a series of experiments in man revealing the presence of a mechanism in the duodenum, stimulation of which accounts for the regulation of the motor and secretory activity of the stomach. Disturbance in the response of the mechanism in duodenal ulcer explains the abnormal motor and secretory activity of the stomach in duodenal ulcer. The report includes a short review of the work done in this field of gastric physiology.

A Clinical Study of Gallbladder Physiology with Roentgen Aid. DAVID S. DANN, M.D., Kansas City, Mo.

Abstract: The extensive experimental and clinical studies of the physiology of the gallbladder reported in the literature, while very valuable, are not entirely conclusive, since they were conducted under conditions which interfere with normal function. The writer has therefore undertaken a clinical investigation to determine normal func-

tion, particularly motor and concentrating activities, under conditions which more closely represent the normal mode of life of the specific individual.

Malignant Salivary Gland Tumors with Bone Metastases. C. LESLIE MITCHELL, M.D., AND G. A. CREEL, M.D., Detroit, Mich.

Abstract: Two long-standing parotid tumors, previously diagnosed as benign, later metastasized to bone and were subsequently shown to be malignant. Case histories of the two patients are presented, with a short discussion.

Medical and Hospital Insurance Problems. ARTHUR W. ERSKINE, M.D., Cedar Rapids, Iowa.

Abstract: An attempt to prophesy inevitable changes in the methods of distribution of medical care, and a discussion of the means the organized medical profession must take to see that they are wise changes. A discussion of the position of radiologists in their relation to mass medical care, the dangers that threaten them, their weakness, and their strength. Some concrete suggestions as to what radiologists must do to insure that their specialty shall continue to endure.

The Fiftieth Anniversary of Roentgen's Discovery of the X-Rays. OTTO GLASSER, Ph.D., Cleveland, Ohio.

Applications of the Inverse-Square Law. ROBERT S. LANDAUER, Ph.D., Highland Park, Ill.

Abstract: There seems to be some doubt qualitatively, but with no quantitative evidence, regarding the application of the inverse-square law to comparatively short skin-target distances with oil-immersed tubes. This paper deals with the quantitative aspects of this problem.

A Practical Technic for Visualization of the Bronchial Tree. MAJOR GILBERT W. HEUBLEIN, M.C., A.U.S.

Abstract: The method of bronchography currently in use at the Percy Jones General and Convalescent Hospital is described. The type of anesthesia used is discussed and the technic for positioning illustrated by line drawings.

The American Board of Radiology. COL. B. R. KIRKLIN, M.C., A.U.S.

Abstract: A discussion of the standards, credit for military service, and future plans and policies of the American Board of Radiology.

Practical Aspects of Hip Nailing. HAROLD W. MORGAN, M.D., Mason City, Iowa.

Abstract: This paper covers a series of 60 consecutive cases treated by internal fixation with Smith-Petersen nail in a small general hospital surgical service. The special equipment used and modifications of previously published procedures which make possible completion of the entire procedure in from fifteen to twenty-five minutes are outlined. There is a report of the end-results so far as can be determined in this series of cases.

Heart Size from Standard Chest Films and Photofluorograms. PAUL C. HODGES, M.D., Professor of Roentgenology, University of Chicago.

Abstract: In ordinary stereoscopic chest films made without any attempt to synchronize the exposure with the cardiac cycle, there is seldom much difference in the size of the two cardiac shadows, and, when correction is made for divergent distortion, either silhouette may be accepted as reasonably comparable to the true frontal plane area of the heart. When the heart shadow is significantly larger in one film than in the other, the larger of the two will be found to be approximately the diastolic size. It is extremely improbable that, in making a stereoscopic pair, both films will show a silhouette significantly less than diastolic size. These facts have had wide tacit acceptance among clinicians. There is, however, much divergence in the opinions as to how the work-up of the silhouette should be done. Transverse diameter is easy but in cardiac disease, obesity, pregnancy, etc., is undependable. Computations based on the actual measurement of frontal plane area are dependable but rather cumbersome. This paper presents technical short-cuts that have been employed in our laboratory for several years and introduces the paper by Dr. Gerhart Schwarz in which the product of the long and short diameters of the silhouette is substituted for planimeter measurements of area. The product of diameters is applicable to either standard size films or miniature films but is particularly useful with the latter.

Correlation Between the Frontal Plane Area and the Product of Long and Short Diameters of the Cardiac Silhouette. GERHART SCHWARZ, M.D., Assistant in Radiology, University of Chicago.

Abstract: A review of the whole subject of roentgen-ray determination of heart size plus the introduction of an equation and nomogram by which frontal plane area may be computed from the product of the long and short diameters of the cardiac silhouette. The particular advantage of this approach is that it avoids the necessity of building up new standards of normal variation and makes it possible to employ the standards that have been accumulated through the years by those who have been measuring the frontal plane silhouette with a planimeter.

Congenital Partial Atresia of the Esophagus Associated with Congenital Diverticulum. R. P. O'BANNON, M.D., Fort Worth, Texas.

Abstract: A newborn infant showed signs and symptoms of congenital atresia of the esophagus with tracheo-esophageal fistula. Autopsy revealed the presence of partial esophageal atresia

with diverticulum. No similar case was found in a search of the literature.

Diagnostic considerations are discussed, and their importance is emphasized in view of the improvement recently achieved in surgery of congenital esophageal anomalies.

Diffuse Pulmonary Adenomatosis. L. W. PAUL, M.D., Associate Professor of Radiology, University of Wisconsin.

Abstract: Human pulmonary adenomatosis is a rare disease of unknown cause characterized by the development of multiple alveolar-cell adenomatous tumors. A brief review of this condition is given and five cases are reported in some detail. The roentgen changes are discussed and illustrated, together with the clinical and pathological findings of interest.

Cephalopelvimetry: Review of 400 Cases. L. A. SCARPELLINO, M.D., Kansas City, Mo.

Abstract: This paper is based upon over 400 cases of pelvic and cephalic measurements, with correction of the growth curve of the fetal head *in utero*, and correlation with the size of the fetal head after delivery. The films were made at various times in pregnancy, from fifteen weeks onward, and the fetal head size was calculated to the delivery date by use of the corrected growth curve. To date, such calculations—regardless of the time in pregnancy that the film is taken—appear to be in agreement with measurements of the delivered head, within an error of ±1 per cent. The method is applicable not only to vertex presentations, but also to breech presentations and twin pregnancies, instances of which are included. Furthermore, a practical method of measuring the asymmetrical pelvis is developed, based on the work of Ball and Marchbank with modifications.

Malignant Melanoma in Infancy: Report of Three Cases. PETER E. RUSSO, M.D., Oklahoma City, Okla.

Abstract: The three cases are as follows: (1) A congenital lesion in a five-weeks-old child proved by biopsy to be melanoma; (2) a similar condition observed in a three-year-old Indian girl, who came to autopsy; (3) a case in a three-year-old colored girl, who, although a metastatic lesion developed, has survived over three years without evidence of recurrence.

Pantopaque Myelography: Diagnostic Errors and Review of Cases. LT. COL. ROBERT C. PENDERGRASS, M.C., A.U.S., AND MAJOR GEORGE L. MALTBY, M.C., A.U.S.

Abstract: This paper deals with the technic, film interpretation, and results of Pantopaque myelography as carried out in an Army General Hospital. Special emphasis is laid upon sources of error in the diagnosis of ruptured intervertebral disks and upon the patterns obtained when the opaque medium is accidentally injected outside the subarachnoid space. The results of 215 Pantopaque myelograms are analyzed, with comparison of the roentgenologic and operative findings in 57 cases. Apparatus used is briefly described, with special mention of a simple device for supporting the fluoroscopic screen above the patient and for obtaining spot films.

Diffuse Calcification of the Pancreas. MAJOR ARTHUR J. PRESENT, M.C., A.U.S., AND MILTON J. GEYMAN, M.D., Santa Barbara, Calif.

Abstract: Diffuse calcification of the pancreas, though rarely reported, probably occurs more frequently than is suspected. The criteria for the diagnosis are presented, with report of two cases.

The Last-Straw Principle in Lower Back Disability. W. WARNER WATKINS, M.D., AND R. LEE FOSTER, M.D., Phoenix, Ariz.

Abstract: This paper is based on a study of 100 cases of lower back disability without visible bone injury, evaluated by the Medical Advisory Board of the Industrial Commission of Arizona, 1934 to 1942.

Some forms of arthritis, especially in the osteoarthritic group, are good examples of attempts at adaptation to stresses on joints or periarticular structures. Such adaptation may be effective over a considerable period, but may finally fail in connection with some trivial stress which represents the "last straw," breaking the adaptation to a long chain of slowly developing changes. When this point is reached and pain develops, with or without trauma, the back is likely to remain painful, unless a persistent and individualized treatment regime is applied to restore the adaptive control of the situation.

Careful study of the x-ray appearances, tracing the development of bone changes, is often helpful in understanding the symptoms and is a good example of the fine art of roentgen interpretation in conjunction with clinical observations.

Roentgen Studies Concerning the Collapsibility of Tuberculous Cavities. ERNST A. SCHMIDT, M.D., Professor of Radiology, University of Colorado, AND CHARLES J. KAUFMAN, M.D., Denver, Colo.

Abstract: The determination of the presence and character of cavitation is of paramount importance in pulmonary tuberculosis not only with regard to prognosis and principles of treatment in general but even more so with regard to the indications for collapse therapy in particular. As a rule, the ordinary inspiration roentgenogram furnishes sufficient information concerning the size, location, wall thickness, and other morphological characteristics of cavities. However, it frequently permits only indirect or inconclusive deductions regarding the collapsibility of the cavities.

The authors have studied the behavior of such cavities under varying physiological and pathological conditions which produce changes in the volume and pressure factors of the thoracic cage (different respiratory phases as well as Mueller's and Valsalva's experiments) and have complemented these findings by tomographic studies. They discuss the practical application of their findings with regard to prognosis and selection of treatment methods.

Bronchography: Method; Anatomical and Pathological Considerations. HUGH F. HARE, M.D., and MAGNUS I. SMEDAL, M.D., Boston, Mass.

Abstract: An analysis of the various methods of bronchoscopy is undertaken. The combined intratracheal and fluoroscopic method has been found a most satisfactory procedure.

The anatomy of the bronchial tree following the classification of Adams and Davenport is discussed.

Some Clinical and Roentgenological Observations of Yaws in the Southwest Pacific Area. MAJOR WALTER J. STORK, M.C., A.U.S., AND MAJOR CARL W. FLEET, M.C., A.U.S.

Abstract: Yaws is the most common disease of the bones, joints, and skin in the tropics. Both acute and chronic cases were observed by the authors in their tour of duty. A series of 886 cases was followed for a period of several months, including the juxta-articular type, goundou, gangosa, crab yaws, and hyperkeratotic types. The roentgen findings in the skeleton are discussed, as well as the clinical and laboratory observations.

Trauma is considered an etiologic factor. That the disease is non-venereal is concluded from the clinical findings and observations. The skin lesions, which are often multiple, have a predilection for the region of the anus and buttocks. Response to arsenicals is dramatic. Symptoms are relieved; large ulcers heal in a few weeks; sclerotic consolidation changes in bone lesions are not unusual. Penicillin produced excellent results in one case of the gangosa type.

Cardiac Roentgenokymographic Findings in Myasthenia Gravis. RICHARD C. BATT, M.D., Berlin, N. H.

Abstract: In 1939 the author detected cardiac roentgenokymographic changes in patients from the myasthenia gravis clinic of the Massachusetts General Hospital. Changes were constantly observed following a test dose of prostigmine. Previous cardiac studies on these patients had all been negative. Although this study shows that there are no characteristic kymographic changes in the heart in myasthenia gravis, kymograms made in the upright position frequently show a slight retardation of the heart rate after prostigmine. Deceptive changes in wave form are constantly produced by this altered heart rate. The chief value of the paper is its revelation of the commoner pitfalls which the unwary physician may encounter in roentgenokymographic diagnosis.

The Range of Usefulness of Intravenous Pyelography. LEONARD A. MYERS, M.D., Houston, Texas.

Abstract: A discussion of the scope of excretory urography in the interpretation of kidney and bladder pathology; preparation of the patient; procedure of examination, with emphasis on individualized attention to the functional status of both kidneys, proper ureteral compression at the period of maximum clearance thrust, a more complete ureteral study, and use of concentrated media for cystographic study.

Coccidioidomycosis with Special Reference to Protracted Primary and Post-Primary Involvement. RAY A. CARTER, M.D., Clinical Professor of Medicine (Radiology), University of Southern California, AND MAJOR HORACE JAMISON, M.C., A.U.S.

Abstract: A correlation of the experience with coccidioidomycosis in a military hospital with that of the Los Angeles County Hospital. A consideration of questions of prognosis, presenting manifestations which are apt to be encountered, and the acute progressive disease in contrast to chronic involvement.

Eosinophilic Granuloma of Bone. LT. COL. JOHN B. HAMILTON, M.C., A.U.S., MAJOR JOHN L. BARNER, M.C., A.U.S., CAPT. PUTNAM C. KENNEDY, M.C., A.U.S., 1ST LT. JAMES J. MCCORT, M.C., A.U.S., AND LT. COL. HANS F. SMETANA, M.C., A.U.S.

Roentgen Findings in and about Lesions of the Shoulder Joint. HARRY A. OLIN, M.D., Associate Professor of Radiology, Chicago Medical School.

Giant-Cell Tumor of Soft-Tissue Origin. MAGNUS I. SMEDAL, M.D., Boston, Mass.

Papers also to be contributed by D. A. RHINEHART, M.D., AND B. A. RHINEHART, M.D., Little Rock, Ark., and by E. R. WITWER, M.D., Detroit, Mich.

THERAPY SECTION

Cancer of the Breast: A Study of Patients Treated over a Period of Twenty Years in the Radiation Therapy Department of Bellevue Hospital. IRA I. KAPLAN, M.D., Professor of Clinical Surgery, New York University Medical School, AND RIEVA ROSH, M.D., Instructor in Surgery, New York University.

Abstract: Patients are divided into three large groups: those who came directly to Bellevue

Hospital for a primary breast condition; those referred from other hospitals for irradiation following surgical procedures; those referred from other institutions or physicians for custodial care or treatment for advanced mammary cancer. Questions of race, age, marital status, lactation, extent and character of the lesion, the presence or absence of metastases are discussed. The relationship of pregnancy and breast cancer is considered.

The methods of irradiation employed are given in detail. Evaluation is attempted of the effect of other forms of therapy used in some cases. The treatment of advanced cases is described. Statistical data are presented, with determination of results as far as possible.

Five Years Experience in General Therapy. ASA SEEDS, M.D., Portland, Ore.

Abstract: Observations on a small teaching tumor clinic and the distribution of service to the public. A philosophic analysis of the opportunities as well as the requirements of a general treatment clinic, both tumor and non-tumor.

Present Status of X-Rays in the Prevention and Treatment of Infections. JAMES F. KELLY, M.D., Professor of Radiology, Creighton University, Omaha, Nebr.

Abstract: Experimental and clinical investigations of x-rays in the prevention and treatment of infections during the past fifty years prove conclusively that the rays affect living cells in a relatively short time, and, as a result, the patient's resistance is increased.

Where irradiation precedes the introduction of the infectious organism or its toxin, an immunity may be found to exist. This effect is easily demonstrated in infections associated with a severe toxemia, such as surgical mumps, gas gangrene, some forms of acute peritonitis, and erysipelas, in which an immunity of short duration may be found. This antitoxic effect of the x-rays may also be noted in some of the more chronic infections, as tuberculous lymph nodes in the neck. It is hoped that the data presented in this paper will lead to a more complete study of some of the infections which, up to this time, have failed to respond favorably to the x-rays but which should do so if irradiation could be given at the proper time and in proper amounts.

Since apparatus capable of influencing infectious diseases is found practically everywhere and its proper use carries little danger, radiotherapy of infections should be encouraged and used by all honest practitioners.

Irradiation in the Treatment of Hypertrophy of the Tonsils and Postpharyngeal Lymphoid Tissue. ANTHONY F. ROSSITTO, M.D., Wichita, Kans.

Abstract: The use of x-rays for infected and enlarged tonsils and adenoids, especially in young children, holds an enviable position in the treatment of these conditions. Roentgen therapy is not used to displace surgical treatment but to forestall surgery. Results seem to indicate that when the lymphoid hypertrophy has been reduced and the infection removed by irradiation, no other therapy is indicated. Because of the consistently good results, the method should be advocated more generally and the treatment should be recognized and encouraged by more radiologists.

Painful Shoulder: Its Diagnosis and Treatment. W. I. LEFEVRE, M.D., Cleveland, Ohio.

Abstract: Discussion of non-traumatic cases only. Diagnosis made both clinically and with plain anteroposterior view of the shoulder. X-ray finding usually negative. Most cases classified as "neuritis" or "bursitis." Treatment with low-voltage x-rays; technic given in detail.

Photography as an Aid in Treating Lesions of the Cervix. CHARLES F. BOWEN, Columbus, Ohio.

Abstract: The most difficult problem in treating lesions of the cervix is to be able to recall (or to have on record) how each looked at each visit. With perhaps fifteen or twenty cases, requiring frequent visits, it is difficult to remember details. With superficial lesions on the body, I have always made photographs as part of my records. After several years of experimenting, I have devised an arrangement of lights which makes it possible to obtain similar records in the case of the cervix. This consists of a ring of lights which fits over a cylindrical speculum. Any type of camera can be used and pictures of any size can be made, either in black and white or in colors.

X-Ray Therapy in Some Common Diseases of the Eye. DALTON KAHN, M.D., Toledo, Ohio.

Abstract: X-ray therapy is indicated in the treatment of many diseases of the eye, especially those accompanied by infection. The relief of pain and of excessive lacrimation is usually manifest in six to eight hours. In some of our cases of corneal ulcer complete healing occurred in forty-eight hours. Small doses with filtration were used in all instances. No damage has been noted as a result of irradiation. Two cases of glaucoma are reported with spectacular relief of pain, although the tension was not lessened.

Eosinophilic Granuloma: Case Reports; Lymph Node Involvement and Therapy. CARROLL C. DUNDON, M.D., AND THOMAS C. LAIPPLY, M.D., Cleveland, Ohio.

Abstract: Eosinophilic granuloma is a destructive lesion of bone which may produce a periostitis and an adjacent soft-tissue mass. Regional lymph nodes may be involved. Lesions have been described in almost all large bones of the body. The

incidence is greatest in the first and second decades of life. The characteristic cell is the histiocyte and there may be many or few eosinophilic leukocytes.

Four cases are presented. One of these patients, a girl 17 years of age, had severe constitutional symptoms which were thought by the clinician to certainly indicate a malignant tumor. A chest wall mass which surrounded the lesion of the sternum measured 12 × 11 × 4 cm. in size. It was not controlled by 1,600 r (air) of high-voltage radiation, but responded to an additional dose of 2,100 r (air). Biopsy was done before and after irradiation. A 6-cm. lymph node of the right axilla showed the typical picture of eosinophilic granuloma. Other lymph nodes were controlled by irradiation. The patient has remained well for six months.

Lymphoepithelioma. GALEN M. TICE, M.D., Assistant Professor of Radiology, University of Kansas.

Abstract: An uncommon, radiosensitive tumor occurring in the nasopharynx. Summary of the literature and report of twelve cases.

Liposarcoma. NORMAN McCORMICK, M.D., Windsor, Ontario.

Abstract: Considerable difference of opinion prevails as regards the radiosensitivity of liposarcomas. Very few instances are recorded in which radiation in adequate dosage has been employed in their management, and brief and incomplete periods of follow-up examination detract considerably from the value of many papers. A satisfactory mode of treatment has not been attained, as, with the possible exception of the less malignant forms, local recurrence and ultimate death from metastasis is the rule.

A single case of liposarcoma, confirmed histologically, has been encountered by us among a series of more than 2,100 cancer patients. This case is reported with clinical photographs of the patient before and after operation, x-rays of the chest, photographs of the pulmonary metastasis, and photomicrographs of the original tumor and its recurrence.

THE CARMAN LECTURE

R. R. NEWELL, M.D., Professor of Radiology at Stanford University, San Francisco, well known for his work in radiation therapy, was chosen by the Program Committee to present the Carman Lecture. His subject was to have been "The Influence of Quality (Wave Length) in Radiation Therapy." The lecture will be presented later in RADIOLOGY as a printed essay.

NOTICE TO DIPLOMATES OF AND CANDIDATES FOR AMERICAN BOARD OF RADIOLOGY

In order to facilitate the mailing out of notices, it is requested that all diplomates of The American Board of Radiology and candidates for certificates who have been in the Armed Services, or for any other reason have changed their addresses in the past two years, notify the undersigned immediately of their present address or an address at which mail will always reach them.

B. R. KIRKLIN, M.D.
Mayo Clinic
Rochester, Minn.

NORTH CAROLINA RADIOLOGICAL SOCIETY

The Fall Meeting of the North Carolina Radiological Society was held at Watts Hospital, Durham, October 5 and 6. Papers were presented by C. L. Gray, M.D., of High Point, N. C.; James E. Hemphill, M.D., of Charlotte; George Baylin, M.D., of Durham; G. B. Murphy, M.D., of Asheville; Paul P. McCain, M.D., of the State Tuberculosis Sanatorium; J. Lamar Callaway, M.D., of Durham; Robert J. Reeves, M.D., of Durham; Vincent Archer, M.D., of Charlottesville, Va.; Hugh F. Hare, M.D., of the Lahey Clinic, Boston, Mass.

SECOND INTER-AMERICAN CONGRESS OF RADIOLOGY

The Second Inter-American Congress of Radiology, originally scheduled to meet in Habana, Cuba, Jan. 19–24, 1946, under the presidency of Dr. Pedro L. Fariñas, has been postponed to Nov. 17–22, 1946. It is hoped that by that date adequate transportation and entertainment facilities can be assured.

A REQUEST FROM THE RADIOLOGISTS OF FRANCE

From Dr. Robert Coliez, President of the Hospital Radiologists of Paris and Vice-President of the Association of French Radiologists, there comes a letter of greeting from French radiologists, with the request that their American colleagues forward to them reprints of papers published since 1938, dealing with all aspects of radiology, electrotherapy, and cancer research and control. Reprints should be addressed to Dr. Coliez, 25, Rue Franklin, Paris, XVIème, France.

"The French radiologists," writes Dr. Coliez, "send to their colleagues of America the expression of their best thanks as well as that of their vivid admiration for the help given and the sacrifices they have accepted for the victory of the Allied Nations."

Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

THE INTERVERTEBRAL DISC, WITH SPECIAL REFERENCE TO RUPTURE OF THE ANNULUS FIBROSUS WITH HERNIATION OF THE NUCLEUS PULPOSUS. Second Edition. By F. KEITH BRADFORD, M.D., Houston, Texas, and R. GLENN SPURLING, M.D., Louisville, Kentucky. A volume of 192 pages, with 70 illustrations. Published by Charles C Thomas, Springfield, Ill., 1945. Price $4.00.

THE MEDICAL ANNUAL 1945. A YEAR BOOK OF TREATMENT AND PRACTITIONER'S INDEX. Editors: Sir HENRY TIDY, K.B.E., M.A., M.D. (Oxon.), F.R.C.P., and A. RENDLE SHORT, M.D., B.S., B.Sc., F.R.C.S. Published by John Wright & Sons Ltd., Bristol, and Simpkin Marshall (1941) Ltd., London.

Book Reviews

PULMONARY TUBERCULOSIS IN THE ADULT: ITS FUNDAMENTAL ASPECTS. By MAX PINNER, M.D., Chief, Division of Pulmonary Diseases, Montefiore Hospital for Chronic Diseases, New York; Editor, American Review of Tuberculosis; Clinical Professor of Medicine, College of Physicians and Surgeons, Columbia University, New York. A volume of 579 pages, with 59 illustrations and graphs. Published by Charles C Thomas, Springfield, Ill. Price $7.50.

This book clearly merits the attention of all who are interested in pulmonary tuberculosis from any angle since it is extremely logical in its presentation of the known facts of the disease, emphasizing its fundamental aspects, and represents an interpretation by an outstanding phthisiologist.

The text contains the important references bearing on the subject and is illuminated by the author's clearly expressed opinions on many therapeutic points concerning which there has been a good deal of past controversy.

It should be a valuable addition to any medical library.

Editor's Note.—Will secretaries of societies please coöperate by sending information to Howard P. Doub, M.D., Editor, Henry Ford Hospital, Detroit 2, Mich.

UNITED STATES

Radiological Society of North America.—Secretary, D. S. Childs, M.D., 607 Medical Arts Bldg., Syracuse 2, N.Y.

American Roentgen Ray Society.—Secretary, Harold Dabney Kerr, M.D., Iowa City, Iowa.

American College of Radiology.—Secretary, Mac F. Cahal, 20 N. Wacker Dr., Chicago 6, Ill.

Section on Radiology, American Medical Association.—Secretary, U. V. Portmann, M.D., Cleveland Clinic, Cleveland 6, Ohio.

ARKANSAS

Arkansas Radiological Society.—Secretary, J. S. Wilson, M.D., Monticello. Meets every three months and annually at meeting of State Medical Society.

CALIFORNIA

California Medical Association, Section on Radiology.—Secretary, Gordon King, M.D., Children's Hospital, San Francisco.

Los Angeles County Medical Association, Radiological Section.—Secretary, Roy W. Johnson, M.D., 1407 South Hope St., Los Angeles. Meets second Wednesday of each month at County Society Building.

Pacific Roentgen Society.—Acting Secretary, Frederick H. Rodenbaugh, M.D., 490 Post St., San Francisco. Meets annually with California Medical Association.

San Diego Roentgen Society.—Secretary, Henry L. Jaffe, M.D., U. S. Naval Hospital, San Diego, Calif. Meets first Wednesday of each month.

San Francisco Radiological Society.—Secretary, Carlton L. Ould, University Hospital, Medical Center, San Francisco 22. Meets monthly on the third Thursday at 7:45 P.M., first six months of the year in Lane Hall, Stanford University Hospital, and second six months in Toland Hall, University of California Hospital.

COLORADO

Denver Radiological Club.—Secretary, A. Page Jackson, Jr., M.D., 304 Republic Bldg., Denver 2. Meetings third Friday of each month, Denver Athletic Club.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Secretary, Max Climan, M.D., 242 Trumbull St., Hartford 3. Meetings bimonthly, second Thursday.

FLORIDA

Florida Radiological Society.—Secretary-Treasurer, J. F. Pitman, M.D., Blanche Hotel Annex, Lake City.

GEORGIA

Georgia Radiological Society.—Secretary-Treasurer, James J. Clark, M.D., 478 Peachtree St., N. E., Atlanta 3. Meets in November and at the annual meeting of State Medical Association.

ILLINOIS

Chicago Roentgen Society.—Secretary, Fay H. Squire, M.D., 1753 W. Congress St., Chicago 12. Meets at the Palmer House, second Thursday of October, November, January, February, March, and April.

Illinois Radiological Society.—Secretary-Treasurer, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—Secretary, Frank S. Hussey, M.D., 250 East Superior St., Chicago 11.

INDIANA

The Indiana Roentgen Society.—Secretary-Treasurer, Harold C. Ochsner, M.D., Methodist Hospital, Indianapolis 7. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Secretary, Arthur W. Erskine, M.D., Suite 326 Higley Building, Cedar Rapids. Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—Secretary-Treasurer, Sydney E. Johnson, 101 W. Chestnut St., Louisville.

LOUISIANA

Louisiana Radiological Society.—Secretary-Treasurer, Johnson R. Anderson, M.D., North Louisiana Sanitarium, Shreveport. Meets annually at same time as State Medical Society.

Shreveport Radiological Club.—Secretary, Oscar Jones, M.D., 2622 Greenwood Road. Meets monthly September to May, third Wednesday, 7:30 P.M.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Secretary, Charles N. Davidson, M.D., 101 West Read St., Baltimore 1.

MICHIGAN

Detroit X-ray and Radium Society.—Secretary-Treasurer, E. R. Witwer, M.D., Harper Hospital, Detroit 1. Meetings first Thursday of each month from October to May at Wayne County Medical Society club rooms.

Michigan Association of Roentgenologists.—Secretary, Bruce MacDuff, M.D., 201 Sherman Bldg., Flint 3.

MINNESOTA

Minnesota Radiological Society.—Secretary, A. Stenstrom, M.D., Minneapolis General Hospital, Minneapolis 26. Meetings quarterly.

MISSOURI

Radiological Society of Greater Kansas City.—Secretary, John W. Walker, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Friday of each month.

St. Louis Society of Radiologists.—Secretary, Edwin C. Ernst, M.D., 100 Beaumont Medical Bldg. Meets on fourth Wednesday of each month except June, July, August, and September.

NEBRASKA

Nebraska Radiological Society.—Secretary-Treasurer, Donald H. Breit, M.D., University of Nebraska Hospital, Omaha 5. Meetings third Wednesday of each month at 6 P.M. in either Omaha or Lincoln.

NEW ENGLAND

New England Roentgen Ray Society.—Secretary-Treasurer, George Levene, M.D., Massachusetts Memorial Hos-

pitals, Boston, Mass. Meets monthly on third Friday at Boston Medical Library.

NEW HAMPSHIRE

New Hampshire Roentgen Society.—Secretary-Treasurer, Richard C. Batt, M.D., St. Louis Hospital, Berlin.

NEW JERSEY

Radiological Society of New Jersey.—Secretary, H. R. Brindle, M.D., 501 Grand Ave., Asbury Park. Meetings at Atlantic City at time of State Medical Society and midwinter in Newark as called.

NEW YORK

Associated Radiologists of New York, Inc.—Secretary, William J. Francis, M.D., East Rockaway, L. I.

Brooklyn Roentgen Ray Society.—Secretary-Treasurer, Leo A. Harrington, M.D., 880 Ocean Ave., Brooklyn 26. Meets fourth Tuesday of every month, October to April.

Buffalo Radiological Society.—Secretary-Treasurer, Joseph S. Gian Franceschi, M.D., 610 Niagara St., Buffalo 1. Meetings second Monday evening each month, October to May, inclusive.

Central New York Roentgen Society.—Secretary-Treasurer, Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse 10. Meetings in January, May, and October.

Long Island Radiological Society.—Secretary, Marcus Wiener, M.D., 1430 48th St., Brooklyn 19. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—Secretary, Wm. Snow, M.D., 941 Park Ave., New York 28.

Rochester Roentgen-Ray Society.—Secretary, Murray P. George, M.D., 260 Crittenden Blvd., Rochester 7. Meets at Strong Memorial Hospital, third Monday, September through May.

NORTH CAROLINA

Radiological Society of North Carolina.—Secretary-Treasurer, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meets in May, and October.

NORTH DAKOTA

North Dakota Radiological Society.—Secretary, Charles Heilman, M.D., 1338 Second St., N., Fargo.

OHIO

Ohio Radiological Society.—Secretary, Henry Snow, M.D., 1061 Reibold Bldg., Dayton 2. Next meeting at annual meeting of the Ohio State Medical Association.

Cleveland Radiological Society.—Secretary-Treasurer, Don D. Brannan, M.D., 11311 Shaker Blvd., Cleveland 6. Meetings at 6:30 P.M. on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*Secretary-Treasurer,* Samuel Brown, M.D., 707 Race St., Cincinnati 2. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—Secretary-Treasurer, L. E. Wurster, M.D., 416 Pine St., Williamsport 8. The Society meets annually.

Philadelphia Roentgen Ray Society.—Secretary, Calvin L. Stewart, M.D., Jefferson Hospital, Philadelphia 7. Meets first Thursday of each month at 8:00 P.M., from October to May, in Thomson Hall, College of Physicians, 21 S. 22d St.

Pittsburgh Roentgen Society.—Secretary-Treasurer, Lester M. J. Freedman, M.D., 4800 Friendship Ave., Pittsburgh 24. Meets second Wednesday of each month at 6:30 P.M., October to May, inclusive, at The Ruskin, 120 Ruskin Ave.

ROCKY MOUNTAIN STATES

Rocky Mountain Radiological Society (North Dakota, South Dakota, Nebraska, Kansas, Texas, Wyoming, Montana, Colorado, Idaho, Utah, New Mexico).—*Secretary,* A. M. Popma, M.D., 220 North First St., Boise, Idaho.

SOUTH CAROLINA

South Carolina X-ray Society.—Secretary-Treasurer, Robert B. Taft, M.D., 103 Rutledge Ave., Charleston 16.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—Secretary-Treasurer, J. Marsh Frère, M.D., 707 Walnut St., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Dallas-Fort Worth Roentgen Study Club.—Secretary, X. R. Hyde, M.D., Medical Arts Bldg., Fort Worth, Texas. Meetings on third Monday of each month, in Dallas in the odd months and in Fort Worth in the even months.

Texas Radiological Society.—Secretary-Treasurer, Asa E. Seeds, M.D., Baylor Hospital, Dallas.

VIRGINIA

Virginia Radiological Society.—Secretary, E. Latané Flanagan, M.D., 215 Medical Arts Bldg., Richmond 19.

WASHINGTON

Washington State Radiological Society.—Secretary-Treasurer, Thomas Carlile, M.D., 1115 Terry Ave., Seattle. Meetings fourth Monday of each month, October through May, at College Club, Seattle.

WISCONSIN

Milwaukee Roentgen Ray Society.—Secretary-Treasurer, C. A. H. Fortier, M.D., 231 W. Wisconsin Ave., Milwaukee 3. Meets monthly on second Monday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, S. R. Beatty, M.D., 185 Hazel St., Oshkosh. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society in September.

University of Wisconsin Radiological Conference.—Meets first and third Thursdays, 4 to 5 P.M., September to May, inclusive, Room 301, Service Memorial Institute, 426 N. Charter St., Madison 6.

CANADA

Canadian Association of Radiologists.—Honorary Secretary-Treasurer, J. W. McKay, M.D., 1620 Cedar Ave., Montreal.

La Société Canadienne-Française d'Electrologie et d Radiologie Médicales.—General Secretary, Origène Dufresne, M.D., Institut du Radium, Montreal. Meets on third Saturday of each month.

CUBA

Sociedad de Radiología y Fisioterapia de Cuba.—Offices in Hospital Mercedes, Havana. Meets monthly.

ABSTRACTS OF CURRENT LITERATURE

ROENTGEN DIAGNOSIS

The Blood Vessels

Technic

RADIOTHERAPY

THE HEAD AND NECK

Basilar Impression Resembling Cerebellar Tumor: Report of a Case. Donald L. Custis and A. Verbrugghen. Arch. Neurol. & Psychiat. 52: 412–415, November 1944.

The authors add another case to the 19 instances of platybasia previously reported by American observers. The condition is generally considered as a developmental anomaly of the craniovertebral boundary characterized by an invagination of the basiocciput due to upward projection of elements of the atlas and axis. The atlas is commonly fused with the occiput. This bony malformation results in encroachment on adjacent neural structures, notably the medulla, cerebellum, cranial nerves, and upper cervical cord. It is difficult, however, to explain why symptoms first appear in adults rather than in children.

The diagnosis rests on roentgenographic demonstration of an appreciable part of the odontoid process above a line drawn from the posterior border of the foramen magnum to the posterior portion of the palatine bone.

The authors' patient was a 55-year-old man with a two-and-a-half-year history of progressive gait instability, as well as other cerebellar signs. Positive roentgenographic signs were present and at operation the cerebellar tonsils were found to be displaced under the lamina of the atlas. Beneath this was a definite bulge of the medulla.

Surgical decompression, including the removal of any constricting bone, dura, or arachnoid, is advocated.

EDWIN O. PEARSON, M.D.
(University of Michigan)

Lateral Movement in the Atlanto-Axial Joints and Its Clinical Significance. J. Dankmeijer and B. J. Rethmeier. Acta radiol. 24: 55–66, Feb. 28, 1943. (In English.)

The authors have made investigations of the possibility of lateral movements of the atlas in relation to the axis, using cadaver material and living subjects. From their observations they conclude that a lateral mobility of the axis in relation to the epistropheus is to be regarded as normal. Roentgenologically these movements can be recognized by an asymmetrical position of the odontoid process in the foramen and by the changed position of the articular surfaces. An asymmetrical position of the odontoid process, however, may also be caused by movement of the axis in relation to the atlas or by an anomaly in the structure of the axis. In view of these observations, prudence is advised in the interpretation of such asymmetry as indicative of an atlas luxation.

MAX SCALITZER, M.D.

THE CHEST

Simple Method for Taking Stereoscopic Chest Films. Stuart P. Hemphill and Melbourne W. Diercks. U. S. Nav. M. Bull. 44: 166–169, January 1945.

The authors describe the use of a sheet of Masonite board, 1/8 in. thick, attached by metal clips to the front of a vertical cassette holder, for taking stereoscopic chest films. The patient is positioned against the board and, without disturbing him or changing his position, the films are inserted in the grooves of the cassette holder. With two persons—one to manipulate the controls of the x-ray machine and shift the x-ray tube between exposures and another to change the cassettes—it was found possible to obtain satisfactory stereoscopic radiographs of the chest within 15 seconds, during which time the average patient can easily suspend respiration in inspiration. This arrangement is not quite so satisfactory as a mechanical plate changer, but inexpensiveness and simplicity make it a valuable addition to ordinary roentgen procedures. With this device, stereoscopic films of other parts of the body, as the skull, cervical and thoracic spine, clavicle, ribs, sternum, and shoulder joints, can be made in addition to chest roentgenograms.

BERNARD S. KALAYJIAN, M.D.

Acute Suppurative Bronchopneumonia. Harold Neuhof and Alexander Thomas. Arch. Int. Med. 75: 45–64, January 1945.

Suppurative bronchopneumonia is the term applied by the authors to the type of bronchopneumonia characterized by suppuration within the parenchyma. Their study is based upon 120 proved cases of this condition seen at Mount Sinai Hospital, New York.

The seasonal incidence of suppurative bronchopneumonia corresponds apparently with that of other forms of bronchopneumonia. As a rule, the disease occurs in persons otherwise apparently healthy, with a higher incidence in children than in adults. The pathogenesis of suppurative bronchopneumonia and non-suppurative aspiration pneumonia seems to be identical. Suppurative pneumonia is often preceded by an infection of the upper respiratory tract and is characterized by fever, cough, and the expectoration of purulent sputum. Thoracic pain occurs early and is sufficiently common to be regarded as a feature of the disease. Physical signs are not distinctive. The pathologic features consist of a severe bronchopneumonia involving one, several, or many portions of the lung or lungs. Spread from primary areas appears to be chiefly by the mechanism of spill-over. Suppurative pleuritis, circumscribed or diffuse, is a common complication. There is no distinctive bacteriologic agent for suppurative bronchopneumonia. One or more of the aerobic pyogenic organisms, most commonly *Staphylococcus aureus*, hemolytic streptococci, and pneumococci, are encountered.

Suppurative bronchopneumonia usually can be diagnosed readily on the basis of the clinical features. When it pursues a prolonged course, it must be differentiated from other causes of pulmonary suppuration, notably, tuberculosis, neoplasm, fungous infection, and even putrid pulmonary abscess.

The roentgen findings in suppurative bronchopneumonia are extremely varied and often bizarre. The occurrence of one or more areas of rarefaction in the midst of pneumonic infiltration was found to be pathognomonic, but such areas are not seen in all cases. They may be revealed by laminagrams when not visible in ordinary films. Other roentgen features, which are encountered so frequently that they can be regarded as

characteristic of the disease, have been classified by Rabin (J. Mt. Sinai Hosp. 8: 32, 1941) as follows: (1) interstitial infiltrations about the bronchi, blood vessels, and interlobular septa; (2) homogeneous densities, either single or multiple, of lobular, segmental, or lobar distribution; (3) changes indicating the presence of focal, segmental, or lobar atelectasis or emphysema; (4) multiple areas of rarefaction indicating the presence of a destructive process within the lung or bronchi; (5) single abscess cavities of varying size; (6) collections of fluid and air within the pleural cavity which may obscure the intrapulmonary changes. These features may exist separately or in various combinations. Roentgenograms which reveal large so-called balloon cavities are of special interest. These thin-walled cavities may be seen in films after apparent complete subsidence of pulmonary infection.

Chemotherapy, including the newer sulfonamide drugs, and serum therapy proved disappointing in the authors' series of cases. Treatment is primarily supportive and when vigorously pursued may greatly facilitate recovery.

Cases are presented illustrating the clinical varieties of the disease, namely the basic localized and diffuse forms, secondary suppurative bronchopneumonia occurring postoperatively or from some other primary cause, and the surgical forms—pulmonary abscess and empyema and pyopneumothorax. Examples of cerebral, septic, and local complications (lattice lung and bronchiectasis) are also presented. Intrathoracic complications account largely for the mortality in suppurative bronchopneumonia. The principles of their surgical management are discussed.

Atypical Pneumonia. By the Commission on Acute Respiratory Diseases. Am. J. M. Sc. 209: 55-58, January 1945.

Primary atypical pneumonia is an acute infection of the respiratory tract, presumably transmitted from person to person by contact, droplets, or droplet nuclei. It may be one or it may be several diseases produced by one or many agents. It may vary from the mildest infection to the most severe and fatal pneumonia. It is by far the most important type of pneumonia in the Army.

It usually begins gradually, with headache, malaise, fever, and chilliness. A dry, irritating, sometimes paroxysmal, cough develops soon after onset. A roentgenogram of the chest will show evidence of infiltration in a large proportion of the cases. As the disease progresses, the cough becomes productive. Physical signs of involvement of the smaller bronchioles appear. Most of the patients are moderately ill from three to eight days, but convalescence is prolonged. Recovery is the rule. Variations from this usual picture may be extreme. Some patients may be sick for weeks, and secondary bacterial infections may develop. Others may be so slightly ill that they continue to work, and only a chest roentgenogram will reveal the presence of the disease. In another group of cases, called "suspected atypical pneumonia," the symptoms are as given above but the chest roentgenogram is normal. These patients have physical signs of pulmonary involvement, however.

The etiology of this disease is still unknown. A clear-cut relationship between the many viruses isolated by animal inoculation and the human disease has not been established. Transmission experiments in human volunteers using throat washings and sputa of patients with the disease suggest that it is an air-borne infection.

Atypical pneumonia has shown no specific concentration with respect to race, sex, or geographic area, except in hospital personnel, in whom the incidence is significantly high. Attack rates in certain of the epidemics have varied from 14 to 40 per cent.

It seems reasonable to consider atypical pneumonia as a more severe form, with pulmonary involvement, of undifferentiated respiratory disease. Proof must await further etiologic studies, but it may be said that this "disease" may constitute a large part of the problem of respiratory illness. Thus far, no intermediary vectors, such as food or insects, have been incriminated. Contact, droplet, and air-borne methods of transmission appear to provide the manner of spread.

BENJAMIN COPLEMAN, M.D.

Primary Atypical Pneumonia of Unknown Cause, with Unusual Manifestations and Complications. Robert E. Glendy, Samuel B. Beaser, and Walter D. Hankins. Arch. Int. Med. 75: 30-38, January 1945.

The 150 cases of primary atypical pneumonia which form the basis of this report were derived from a total of 180 cases of pneumonia of all types encountered at an Army station hospital from Sept. 1, 1942, to June 1, 1943. Complications noted among the 150 cases were: meningismus in 3 cases, pleural effusion in 4, pronounced leukopenia in 1, infiltration simulating tuberculosis and a spontaneous pneumothorax in 1, pulmonary abscess in 4, and late secondary infection in 2. A number of these cases are presented in detail.

One of the cases of primary atypical pneumonia with meningitis illustrates the complete ineffectiveness of sulfadiazine in primary atypical pneumonia and infection of the throat by secondary invaders late in the disease. Another is of particular interest because of the presence of leukocytes in the spinal fluid, with a late secondary infection of the middle ear.

The authors call special attention to the roentgen features in the cases of atypical pneumonia with pleural effusion. Clinically it was noted that effusion occurred in patients with severe symptoms, a considerable degree of prostration, a high remittent fever, and a strong tendency to relapse. One patient had a leukopenia with a marked outpouring of immature cells in addition to the pleural effusion. The white blood cells rose on the day of defervescence, but the abnormal cells persisted longer. The patient was allowed up before the fluid was completely absorbed and had a relapse, which was accompanied by spread to the upper lobe of the right lung without further hemopoietic complications.

In one case the pneumonia simulated tuberculosis, with a subsequent spontaneous pneumothorax. The patient was admitted to the hospital with a manic depressive psychosis. Physical examination seemed essentially normal, and the temperature was normal throughout the period of hospitalization except for an elevation to 99° F. on the first two afternoons. Roentgenograms of the chest taken two weeks after admission showed a soft cottony infiltration in the infraclavicular region extending out into the first interspace from the hilus. Subsequent films showed complete clearing of the infiltration, but a small apical pneumothorax, extending down as far as the first and second interspaces.

The cases of pneumonia with a putrid pulmonary

abscess presented here are unlike those reported elsewhere. The resemblance of this lesion to tuberculous cavitation, especially when located in the upper pulmonary fields, is noteworthy. Tuberculosis was ruled out in the authors' cases by the clinical course and laboratory studies. The abscess seemed to be the result of infection by secondary invaders during convalescence, occurring on the nineteenth, thirteenth, sixteenth, and forty-second day in the 4 patients with this complication. The only death in the entire series was in a case of secondary infection with pulmonary abscess and empyema.

Two cases illustrate the occurrence of fever, leukocytosis, spread of the pneumonia, and prompt response to sulfonamide compounds during convalescence.

Numerous roentgenograms are reproduced.

Bronchography in Pulmonary Tuberculosis: Chronic Fibroid Phthisis—Chronic Productive Tuberculosis. B. A. Dormer, J. Friedlander, and F. J. Wiles. Am. Rev. Tuberc. 51: 62–69, January 1945.

Chronic fibroid phthisis is a difficult type of tuberculous disease to treat. Many patients have had the disease for years with sputum positive for tubercle bacilli and with the diagnosis made more or less by accident. Treatment seems well-nigh impossible because of the almost universal bilateral nature of the disease, its extent, and the low vital capacity and dyspnea which accompany it. Bronchography has been found to demonstrate the essential lesions much more clearly than conventional radiography. The pathological development seems to follow the course of bronchial block with atelectasis and pneumonitis, to be followed by bronchiectasis and excavation. Suspension of sulfonamide powder or sulfadiazine, as much as 2 gm. to each 5 c.c. of iodized oil, was found to improve the clarity of the bronchograms. In 3 cases repeated instillations of this mixture resulted in the disappearance of tubercle bacilli from sputum which had been positive for many years. It is suggested that this suspension may sterilize chronic bronchiectatic areas and cavities in cases of this type. This same form of treatment was used preceding major surgery, as thoracoplasty, and the postoperative course appeared to be smoother in all respects than in any earlier series of cases. Ten case reports with reproductions of bronchograms are included. L. W. PAUL, M.D.

Radiological Findings in Tracheo-Bronchial Tuberculosis. C. C. Birkelo and L. A. Poznak. Dis. of Chest 11: 26–35, January–February 1945.

Endobronchial tuberculosis is commonly found in small and large bronchi near the cavities which they drain. It is seen less frequently at points distant from cavities. Bronchoscopy is the method of choice both for diagnosis and treatment, but frequently reliance must be placed on the physical and roentgen examinations in selecting cases for bronchoscopic study. The authors group certain suggestive x-ray findings as direct and indirect. The direct findings are as follows:

(1) Small areas of atelectasis without visible shift, usually in an apex, resulting from occlusion of smaller bronchi.

(2) Sudden consolidation of a lobe in a partially collapsed lung. This may be due to a blood clot, but it may be the result of a bronchial ulceration with stenosis and is a direct indication for bronchoscopy.

(3) Sudden spread of a lesion which had been apparently controlled by pneumothorax or other collapse procedure.

(4) Sudden variation in size of cavities or a cavity with considerable fluid. This may be caused by stenosis, kinking of a bronchus, or endobronchial tuberculosis, such as a tuberculoma or ulceration with stenosis. Failure of a cavity to close or diminish in size following adequate collapse measures also indicates bronchial occlusion.

(5) Endobronchial tuberculosis should be suspected in far-advanced disease with multiple and bilateral excavations.

Indirect signs of tracheobronchial tuberculosis are (1) hemoptysis of the mild or streaking type without demonstrable x-ray changes; (2) positive sputum without a demonstrable cavity; (3) persistent non-productive cough with minimal roentgen findings.

The authors add a table showing the results of bronchoscopic examination in 565 cases, which they group as "prior to collapse" (224 cases) and "suspected tracheobronchial disease" (341 cases). In 417 the examination was negative; ulceration or stenosis was present in 148.

[This paper is one of a Symposium on Tracheobronchial Tuberculosis presented before the American College of Chest Physicians, comprising this entire issue of Diseases of the Chest.] HENRY K. TAYLOR, M.D.

A Particular Type of Tuberculous Pulmonary Cavitation Tending to Heal Spontaneously. Lasar Dunner. Brit. J. Radiol. 17: 274–277, September 1944.

This report is based on the observation of 16 tuberculous patients ranging in age from fifteen to thirty-two. Each presented a circular, thin-walled cavity with no translucency, associated with a miliary type of spread. Tubercle bacilli were found in the sputum in every case. Physical signs were slight or absent. The symptoms were those of early pulmonary tuberculosis. The cavities all disappeared, sometimes faster, sometimes slower, than the other infiltrations, in periods varying from nine to thirty-six months. Since none of these patients had received any of the usual therapeutic measures, as artificial pneumothorax, phrenic avulsion, etc., the author suggests that a conservative attitude should be adopted in cases manifesting this "cavitation complex." SYDNEY J. HAWLEY, M.D.

Bronchoeolic Fistula. Russell Buxton and Rachelle L. Kurman. Am. J. Surg. 67: 137–139, January 1945.

This case is the second of bronchoeolic fistula to be recorded. A 9-year-old colored boy was admitted to the hospital with a diagnosis of gangrenous appendix with perforation. He was operated on immediately and the diagnosis was proved to be correct. His postoperative course was one of infection with elevation of temperature and severe secondary anemia. On the twenty-eighth postoperative day the temperature rose to 105°, with coughing, spitting, and vomiting of a bloody purulent material. Roentgen examination showed consolidation of the base of the right lung. On the sixtieth postoperative day one ounce of 1 per cent mercurochrome was injected into the draining abdominal sinus and for twenty minutes the patient spit up mercurochrome-tinged sputum. A fistulous tract connecting the right lower quadrant opening with the lung seemed probable. Skiodan was injected into the appendiceal fistula and a film revealed a sinus tract which

could be traced upward behind the liver, extending through the diaphragm into a bronchus in the right lung. The patient was discharged with the fistula still draining. Nine months later he had apparently recovered except for a slight cough, and two years later he was reported to be completely normal. A roentgenogram is reproduced.

Radiological Diagnosis of Myocardial Infarction. David R. Cameron and Peter J. Kerley. Lancet **1**: 52–53, January 13, 1945.

Recent studies have suggested that myocardial infarction can now be diagnosed accurately by fluoroscopy in a high proportion of cases. Master (J. Mt. Sinai Hosp. 6: 18, 1939) describes a local diminution, absence, or reversal of movement of the left ventricular silhouette in the infarcted area; he found one or other of these changes in 66 out of 100 cases of infarction. The abnormal pulsation was commonly noticed in the apical or supra-apical portion of the left ventricular outline. Master considered that the abnormality, if visible in the postero-anterior view, represented an anterior or posterior infarct, while if it was seen in the left oblique or lateral view, it represented a posterior infarct. Levene and Lowman (Radiology **36**: 159, 1941), in addition to alteration in pulsation, describe a loss of convexity of the left cardiac border in typical cases of infarction.

In order to determine the value of fluoroscopy in the diagnosis of infarction, 27 patients with certain or probable myocardial infarcts and 10 controls were examined, with the patient's history and electrocardiographic findings unknown to the roentgenologist. Since the patients were ushered one after another into a darkened room, it was not possible for the examiner to be biased by their facies or apparent age.

The left ventricular border was examined in the postero-anterior view or with slight rotation to the left, and again in the left anterior oblique or in such an approximation to it as would insure the clearest view. No account was taken of an altered heart shape, but diminution, reversal, or absence of pulsation was noted. If one of these was seen in the postero-anterior view, an anterior infarct was assumed; if in the left oblique, a posterior infarct. No more accurate localization than this was attempted. It was later realized that the left oblique view was not the best in which to look for a posterior infarct, for this lesion is apparent as often as not in postero-anterior films. In addition, the greater amplitude of movement normally seen in the left oblique position makes it more difficult to detect local changes. In both views the apical and supra-apical regions were particularly observed.

Results of this study in 14 patients with positive clinical evidence of infarction, confirmed by electrocardiography, with localization of the site, show that fluoroscopic diagnosis of anterior infarction is accurate, but that both the site and occurrence of a posterior infarct are more difficult to define.

Six patients had a history of infarct, with electrocardiograms showing either auricular fibrillation or bundle branch block. Deductions as to the reliability of fluoroscopy cannot be made on such a small number of patients, but it is obvious that accurate x-ray diagnosis would be of great value in obscure cases of fibrillation due to infarction.

The findings in a group of 7 patients in whom either the history or the electrocardiogram was equivocal again show that roentgen diagnosis is more reliable in anterior lesions, which, in any case, are more likely to show convincing electrocardiographic findings. It is clear, however, that fluoroscopy can be of great value in cases of infarction masquerading as dyspepsia or a biliary attack.

In the fourth group, consisting of 6 patients with cardiac abnormalities other than infarction and 4 normal persons, an anterior infarct was diagnosed in one case with a slight left ventricular enlargement, but no clinical or electrocardiographic suggestion of infarct.

This study seems to show that anterior infarction can be diagnosed and localized accurately by fluoroscopy. The alterations in the movements of the heart are probably contributed to by a thickened or adherent pericardium at the site of infarct. The authors conclude that it is probably wrong to look for signs of a posterior infarct in the left anterior oblique position.

Preoperative Diagnosis of Patent Ductus Arteriosus. M. J. Shapiro. J. A. M. A. **126**: 934–937, Dec. 9, 1944.

Clinical findings in 62 patients with patent ductus arteriosus are presented and the importance of a correct preoperative diagnosis is stressed. The diagnostic criteria are listed as follows: (1) machinery murmur, (2) thrill in the pulmonary area, (3) enlarged pulmonary artery, (4) enlarged, pulsating pulmonary vessels, (5) enlarged heart, (6) increased pulse pressure, (7) stunting of growth, (8) absence of cyanosis or clubbing of the fingers, (9) normal electrocardiogram, (10) history of cardiac lesion from birth.

Fluoroscopic and roentgenographic examinations are of considerable value as aids in diagnosis, as well as in following the progress of the individual case.

The author feels that a great deal can be learned by x-ray methods in regard to the severity of the leak and the amount of cardiac strain. Differential diagnosis from other types of heart disease and from the so-called venous hum is considered. It is suggested that no case be treated surgically unless the findings are characteristic.

MARVIN J. SHAPIRO, M.D.
(University of Michigan)

Right Retroperitoneal Diaphragmatic Hernia. N. R. Barrett. Brit. J. Surg. **32**: 421–425, January 1945.

Roentgen examination of the thorax in a man of 52 complaining of abdominal pain and dyspnea on exertion revealed an opacity at the base of the right chest which merged with the shadow of the diaphragm and liver below, with a definite upper margin extending transversely across the lower third of the right lung field. Later x-ray studies, following a diagnostic pneumothorax, showed the mass to be extrapulmonary, posterior to the pleural cavity, and separate from the chest wall. It was lobulated and contained areas of different density. A barium meal examination showed some deformity of the duodenal cap but nothing else of significance.

The diagnoses considered were diaphragmatic hernia, tumor of the chest wall, and tumor of the diaphragm. The possibility of hernia was rejected because no part of the intestinal tract was demonstrable in the thorax, the fact that solid viscera can pass into the chest without being accompanied by intestine being entirely disregarded. The other two diagnoses having been eliminated, a thoracotomy was advised. At this time the patient volunteered the information, for the first time,

that he had been stabbed in the back by a narrow-bladed knife twenty-six years previously, and a small scar was discovered over the right tenth rib, 3 inches from the mid-line.

At operation the mass was found on the upper aspect of the diaphragm, as demonstrated radiologically. It proved to be a retroperitoneal diaphragmatic hernia containing the right kidney surrounded by perinephric fat. There was no hernial sac; the aperture in the diaphragm was 3 1/2 inches long. The patient made a complete recovery.

Diaphragmatic hernia is more common on the left side. The explanation of this varies with the type of hernia. In cases due to congenital malformation of the diaphragm, the defect occurs about the eighth week of intra-uterine life, at which time the pleuroperitoneal canal on the right will presumably be closed, while closure of the corresponding canal on the left is likely still to be incomplete. A left-sided lesion is also favored by the fact that at this stage of development, the liver is entirely right-sided, the stomach has reached its adult position below the diaphragm, and the left lung is smaller than the right. Thus it is not only easier for a left-sided hernia to occur, but there is more space in which it can be accommodated. The author believes that left-sided para-esophageal hernia is the commoner variety because the hiatus lies to the left of the mid-line and the stomach and spleen, which are the usual contents of the hernia, are on the left. The chance of traumatic perforation of the diaphragm is equal upon the two sides of the body, but the risk of subsequent hernia is greater upon the left because the liver seals the gap with greater certainty than does the stomach, spleen, or colon.

The importance of hernia due to small penetrating wounds of the diaphragm lies in the fact that there are no signs or symptoms until the hernia has attained considerable size. In the performance of thoracotomies for chest wounds, the author has observed perforations of the diaphragm which were soon sealed by a small plug of omentum, but while this may cure the condition, it may also act as the apex of a hernia, more and more of the abdominal contents being forced into the pleural cavity over a long period of time. This accounts for large diaphragmatic hernias discovered only after a lapse of many years following injury.

The diagnosis of hernia is generally based on demonstration of some part of the gastro-intestinal tract in the thorax, but the fact that solid viscera, as the kidney, liver, or spleen, may be the only ones to pass through the opening should not be overlooked.

MAX CLIMAN, M.D.

Congenital Diaphragmatic Hernia. Visceral Strangulation Complicating Delivery. J. W. Thompson and Leo J. LeBlanc. Am. J. Surg. 67: 123–130, January 1945.

A case of congenital diaphragmatic hernia complicating the puerperium [rather than delivery] is presented. The first pregnancy, labor, and puerperium of this patient, a 31-year-old white woman, had been without incident. About five hours after the spontaneous delivery of her second child, the patient complained of severe epigastric pain and was very restless. She became nauseated and vomited several times. Respirations were labored and accelerated. There was mild cyanosis and the patient appeared alarmingly ill. Administration of oxygen per nasal tube was begun.

Examination of the chest revealed a splinted left thorax. The lower two-thirds of the chest were dull to percussion, and no breath sounds were audible on this side. The heart sounds were best heard well within the midclavicular line; there was possible cardiac dullness to percussion to the right of the sternum. The right chest was resonant to percussion and the breath sounds were normal. The abdomen showed the usual postpartum contour, moderate distention, and generalized tenderness. A mass, which was thought to be an enlarged spleen could be palpated in the left upper quadrant.

Roentgenograms of the chest and abdomen, taken in the patient's room revealed increased density throughout the entire left lung field. The heart and mediastinal structures were shifted to the right. There was a distinct irregularity of the left diaphragm. The stomach, well outlined by entrapped air, was displaced into the left thorax. The tip of the indwelling nasal tube was in the stomach. A diagnosis of left-sided diaphragmatic hernia with progressive strangulation of the hernial contents was made and exploration was carried out.

A large congenital diaphragmatic hernia, through which all of the hollow viscera of the abdomen had migrated into the left thorax was found. The mesenteries of the stomach and intestines were elongated and there had been a complete counterclockwise rotation, causing torsion of the pancreas, which was acutely inflamed and covered by a fibrino-plastic exudate with numerous areas characteristic of superficial fat necrosis. The only organs remaining in the abdomen were the spleen, which was enlarged to about twice its normal size, the liver, which was also enlarged and extended three or four fingerbreadths below the costal margin, and the descending colon. The viscera were easily replaced within the abdominal cavity and the hernia repaired. On the eleventh postoperative day, roentgenograms of the chest showed an almost complete collapse of the left lung with an extensive pneumothorax of the same side. There was a marked depression of the left diaphragm. No fluid level could be seen. The patient was discharged from the hospital on her thirteenth postoperative day in excellent condition. The breath sounds and percussion notes gradually became normal, and a chest film about two and a half months following delivery showed that the left lung had completely expanded except at the costophrenic angle. Roentgen studies of the thorax and gastro-intestinal tract at this time revealed a low-lying, atonic stomach situated below the left leaf of the diaphragm. The motion of the diaphragm might possibly be considered slightly restricted. The colon was redundant and atonic. That the mesenteries were still abnormally elongated could be demonstrated by the ease with which the barium-filled viscera could be manipulated to distant corners of the abdominal cavity.

Diaphragmatic hernia is not a common complication of pregnancy. Four fatal cases diagnosed during pregnancy have been reported. Two cases of diaphragmatic hernia complicating the immediate puerperium, treated by conservative measures, without fatality, are all that the literature supplies. The authors' case is believed to be the first one in which the patient was operated upon with a successful result. In order that such congenital anomalies may be recognized, and appropriate treatment carried out, careful clinical and roentgen studies of the thoracic organs of pregnant women are of paramount importance.

THE DIGESTIVE SYSTEM

Melanoma of the Small Intestine. Peter A. Herbut and Willis E. Manges. Arch. Path. 39: 22–27, January 1945.

Approximately 25 cases of melanoma of the small intestine have been recorded in the literature. In 9 of these the tumor was reported as primary in the small bowel, in 16 as metastatic. To the latter group the authors add 5 cases. In 3 of the cases the neoplasm originated in a cutaneous nevus, while in 2 the primary site was not determined. Abdominal pain, frequently with other symptoms of intestinal obstruction, was present in 18 of the 30 cases now on record, and intussusception occurred in 10.

The authors believe that melanoma of the small bowel is usually, if not always, metastatic, for melanoblasts have not been demonstrated in the small intestine and the involvement of the bowel in known secondary melanoma is the same as in cases in which the tumor is thought to be primary. Primary cutaneous growths may be lost sight of in the often delayed metastasis peculiar to melanoma. Occasionally quiescent moles give rise to local and distant metastases. Autopsies are often, of necessity, too limited to reveal the site of a possible primary growth.

Multiple Polypoid Disease of the Colon and Rectum. H. L. Pugh and J. P. Nesselrod. Ann. Surg. 121: 88–99, January 1945.

Multiple polypoid disease of the colon, termed also polyposis, polypoidosis, and multiple adenomatosis, is a distinct entity and is to be distinguished from single or multiple polypi resulting from irritation or infection. Although multiple polypoid disease occurs infrequently, it is of great importance because it is attended by an extreme predisposition to malignant change. Patients with this condition are almost certain to die with cancer at an early age unless radical surgery is instituted promptly. Multiple polypoid disease is familial or inheritable, attacking both sexes and transmissible by both.

While proctosigmoidoscopic examination will reveal the presence of polypi in the majority of patients, a roentgen study of the colon should be carried out in each case. The importance of a contrast film following the injection of air after the barium has been evacuated cannot be overemphasized. Roentgenograms in the authors' two cases demonstrate the value of this procedure.

Radical surgical intervention, namely, total colectomy, is warranted and carries with it the only hope of permanent cure. Ileosigmoidostomy followed by resection of the intervening segment may be done in lieu of total colectomy in cases where the lesion in the rectum and rectosigmoid can be removed by fulguration. A case illustrating each of the surgical procedures is reported.

Roentgenologic Examination of Acute Appendicitis. Ragnar Steinert, Ingvard Hareide, and Thorolf Christiansen. Acta radiol. 24: 13–37, Feb. 28, 1943. (In English.)

One hundred and four cases of acute appendicitis were observed roentgenologically and verified by operation. Examinations were made without contrast medium, with the patient supine and erect or, if he were unable to stand, in left lateral decubitus.

In 80 cases, the roentgen examination demonstrated deviations from the normal. Concretions in the appendix were visible in about 10 per cent, approximately one-third of those cases in which concretions were found at operation. In all cases with roentgenologically visible concretions, a gangrenous or perforated appendix was found at operation.

A local density lateral to the cecum may be due to a perforated appendicitis or to a small appendiceal abscess, but ordinary gangrenous, non-perforated appendicitis is also to be considered.

Acute appendicitis was not always characterized by gas accumulation in the cecum. Occasionally, the cecum is empty of gas.

Fluid levels in the cecum constituted a frequent and characteristic finding. They were also found in the small intestines, particularly in the terminal loops of the ileum.

Reduced excursion of the diaphragm on the right side was always observed in acute appendicitis. Obliteration of the right flank stripe was noted in cases of severe appendiceal inflammation and especially of perforation. Effacing of the right psoas shadow and left convex lumbar scoliosis could be seen in all grades of acute appendicitis.

Typical roentgen features of acute appendicitis may be seen four and a half hours after the onset of the attack. MAX SGALITZER, M.D.

Roentgenologic Examination of the Intrahepatic and Extrahepatic Biliary Tract (Cholangiography). Aguinaldo Lins. Rev. med. Panamericana 1: 185–193, August–December 1944.

The author reviews the subject of cholangiography since 1915, giving several excellent illustrations covering the method, considered just as important to the surgeon as is electrocardiography to the cardiologist. The advantage of making cholangiographic examinations during operation is stressed in cases of inflammation involving the sphincter of Oddi, in stenosing pancreatitis, and choledocholithiasis. Barium sulfate, lipiodol, iodochloral, and Hippuran are the contrast media of choice. The author believes that refinements of the Graham-Cole technic may reduce cholangiograms in the future. In conclusion, he compares the examination of the biliary tree to that of the urinary tract. SEBASTIAO V. FRANCO, M.D.

Spontaneous Internal Biliary Fistulae. W. H. Beekhuis. Acta radiol. 24: 38–44, Feb. 28, 1943. (In German.)

The author reports a case of spontaneous internal biliary fistula due to perforation of a duodenal ulcer into the common bile duct. The diagnosis was made roentgenologically and was verified at operation.

MAX SGALITZER, M.D.

THE SPLEEN

Radiological Estimation of Splenic Enlargement in Malignant Tertian Malaria. W. H. T. Shepherd. Brit. J. Radiol. 17: 280–285, September 1944.

This report is the outcome of a study conducted in an overseas area where malignant tertian malaria is hyperendemic. Its author was with the British R.A.F.

The spleen is examined with the patient prone and rotated approximately 10° to the left. With bed patients preparation is advisable; in others it is usually not necessary. For the average patient the factors are: 80 kv. and 80 ma. sec.; medium speed intensifying screens and Potter-Bucky diaphragm; anode film distance 36 inches.

The radiographic splenic index is the product of the length by the breadth in inches. Any index below 8 is regarded as normal. Between 8 and 12 is regarded as 1-plus enlargement; above 12 as 2-plus enlargement.

Of 19 cases of malignant tertian malaria studied radiographically on admission, 8 showed an index above 8. Of 10 cases of clinical malaria, 6 showed a raised index. Four of 8 patients with other disease (regional ileitis, non-specific enteritis, staphylococcus folliculitis, and vaccinia) showed a raised index. The patient with regional ileitis had had two previous attacks of malaria.

Radiography is more accurate than palpation in detecting an enlarged spleen. The spleen is not palpable until the index reaches 9 1/2.

SYDNEY J. HAWLEY, M.D.

Roentgenologic Examination of the Abdomen as an Aid in the Early Diagnosis of Splenic Injury. James F. O'Neill and J. P. Rousseau. Ann. Surg. **121:** 111–119, January 1945.

Damage to the spleen is probably the most common serious intra-abdominal injury resulting from blunt force. Clinically, three types of injury may occur: (1) extensive rupture with immediate massive hemorrhage, (2) small lacerations which ooze blood slowly over a period of hours or possibly days, and (3) delayed rupture. When the injury to the spleen is of the first type, the diagnosis is usually made easily and splenectomy is carried out. Injuries of the second and third types are difficult to diagnose in the hours immediately following trauma, especially in the presence of associated injuries. The symptoms and signs may disappear completely or so improve that the patient may be allowed to resume full activity. Then, after a latent period of hours, days, or even months, secondary hemorrhage may occur, usually of such severity that circulatory failure promptly ensues.

The time to remove a slowly bleeding spleen is early, before blood loss threatens life. Diagnosis must, therefore, be made early. Clinical symptoms and signs may be equivocal. Hematologic studies may or may not be of aid. Abdominal aspiration or peritoneoscopy have been advocated, but these examinations are more difficult and more dangerous than the taking of a plain film of the abdomen. The latter can be of great assistance in establishing early the diagnosis of a lacerated spleen. Solis-Cohen and Levine (Radiology 39: 707, 1942) on roentgen examination of the abdomen in three cases, observed an obliteration of the splenic shadow and a dilated stomach, with serration of the greater curvature. In each case the diagnosis of splenic damage was confirmed at celiotomy. In plain films of the abdomen of 100 patients with no demonstrable splenic lesions these findings were not encountered.

The authors studied 3 patients with non-penetrating trauma to the left upper quadrant, left flank, and left lower thorax. One of these patients had a lacerated spleen and two fractured ribs, with no evidence of any other lesion; the plain film of the abdomen demonstrated very clearly the signs described by Solis-Cohen and Levine. The roentgen findings in the second patient, who had a laceration of the spleen as well as damage to the left kidney, were also characteristic. In both these cases the appearance of the curvature became normal following operation. In the third patient, with a shattered kidney and a normal spleen, the greater curvature was smooth and the stomach contained much gas; the left kidney shadow was obliterated and the left psoas shadow obscure.

These observations corroborate those of Solis-Cohen and Levine. It is evident that the gas-containing stomach, with the serrated greater curvature, will show on a plain film of the abdomen when the splenic laceration is small or moderately large. These findings still occur when some other viscus in addition to the spleen is injured, but are absent when the kidney is ruptured in the presence of a normal spleen and following splenectomy.

Further experience with these roentgen criteria for damage to the spleen is necessary. The importance of plain films of the abdomen and chest when splenic damage is suspected is stressed, not alone to help evaluate the injury to the spleen, but to determine possible associated thoracic injuries.

THE SKELETAL SYSTEM

Plasticity of Bone. James F. Brailsford. Brit. J. Surg. **32:** 345–357, January 1945.

This paper is the Hunterian Lecture delivered at the Royal College of Surgeons of England on April 26, 1944. Beginning with two brief quotations from a lecture by John Hunter on "Diseases of Bones and Joints," which dealt with rickets and pointed out how the plasticity of bone may produce various deformities of the spine, pelvis, hip, etc., the author reviews the histology and embryology of normal bone. Prior to the deposition of mineral matter, the pre-osseous tissue, or matrix, is plastic and can be compressed and deformed by stresses and strains, the final effect of which will depend upon their duration, the changes wrought in surrounding structures and their shape and position at the time setting of the matrix takes place. With the deposition of crystalline salts of calcium, such as we see in calcification, no material contribution is made to the rigidity and strength of bone, as is demonstrated in fetal osteogenesis imperfecta and in one stage of avascular necrosis of bone. With the incorporation of colloidal calcophosphate mineral matter, the pre-osseous matrix undergoes a rapid setting and the bone acquires a rigidity, resilience, and a related fixation of form which is not altered by normal function. Normal ossification, beginning in an ossific nucleus, spreads uniformly and gradually from the regular center to the periphery of the cartilaginous mass. It is not deformed by the normal stresses and strains of the growing child.

If, however, ossification in any site is irregular and multiple irregular ossific centers develop throughout the cartilaginous structure, the latter will not withstand normal function. Due to irregular deposition of mineral matter it loses its elasticity and becomes plastic and therefore liable to compression and deformity. Examples of this can be seen in hypothyroidism, in the form of spinal deformities with irregular ossification of vertebral bodies and, in older children, changes in the

femoral capital epiphysis resembling a healed Legg-Perthes' disease.

In cases of paralysis there is a gradual decalcification of bones of the affected part. Scoliosis of the spine in children following one of the exanthemata is progressive, possibly due to weakness of spinal musculature.

Plasticity due to generalized changes in bone is represented by osteogenesis imperfecta, with deformities dependent on gravitational and muscular pulls; the active phase of infantile rickets and renal rickets, especially when associated with hyperparathyroidism; and the skeletal changes in hyperparathyroidism associated with a parathyroid tumor.

The most notable example of plasticity limited originally to one bone is Paget's disease, or osteitis deformans. This condition may begin in one bone or in widely separated bones. The radiographic appearance may exhibit three distinct types of bone changes: (1) osteoporotic, (2) osteolithic, (3) lithocystic. The first type shows general expansion of bone, osteoporosis, coarse trabeculations, and bending under normal strains. Fractures may occur. The concave aspect is condensed while the convex aspect shows one or more incomplete fractures from periphery to the center. The osteolithic bone is much denser than normal and is abnormally fragile and easily fractured. This type simulates metastatic carcinoma. In the lithocystic form the bones eventually show massive development with thickening of the dense cortex, within which cyst-like areas of various size occur.

Polyostotic fibrous dysplasia is another condition which produces plasticity of bone locally or throughout the skeleton, resulting in great deformity. The lesions are cystic in appearance, occurring in long bones and skull. There is no general decalcification and the unaffected parts of the skeleton show normal cancellous and compact tissue.

Among characteristic changes in various skeletal elements exhibiting abnormal plasticity, the author lists basilar impression, scoliosis and kyphosis, spondylolisthesis, and protrusio acetabuli.

Localized plasticity of bone may also be due to trauma. This is seen more commonly in the spine, particularly in young persons in whom ossification is incomplete, engaged in occupations requiring continuous bending. Compression is exerted on the anterior aspects of the dorsal vertebral bodies; reactive inflammatory changes may be induced in the tissues under compression, and localized decalcification with plasticity results. Later re-ossification fixes the deformity. Continued pressure leads to condensation of the opposing bony surfaces and ossification of the adjacent ligaments. Any lesion, whether it be developmental, traumatic, inflammatory, or neoplastic in origin, which alters the normal alignment or balance of the skeleton, will cause abnormal strains to be placed on some structure and sooner or later this will show the reactive changes similar to those described in the spine.

In osteochondritis the affected bone is plastic and can be deformed by pressure from adjacent bones. In Legg-Perthes' disease (osteochondritis deformans juvenilis) of the femoral capital epiphysis the bone exhibits abnormal plasticity for three to four years. In the infant scaphoid and the vertebral body the time is speeded up and within a year or a year and a half the affected bone has been sufficiently reconstituted to permit of normal function.

Trauma has been suggested as an etiologic factor in the localized lesions of osteochondritis. Undoubtedly trauma can produce avascular necrosis of bone. It is seen more commonly following fracture of the femoral neck or carpal scaphoid, and the most important feature is that the necrotic fragments excite inflammatory reactive changes in the adjacent vascular bone, leading to its decalcification and abnormal plasticity, until the necrotic bone has been removed or entirely reconstituted.

In fractures of the neck of the femur with fragments held in position by a Smith-Petersen pin or any other metal nail, there may be radiographic evidence of good alignment and some union after a fairly long interval. If weight-bearing is permitted at this stage and there is a certain amount of pain accompanying the use of the limb, one should be careful to exclude avascular necrosis. Otherwise, the pin will go through the plastic bone of the femoral head or neck. In a previous paper the author had pointed out that unless a patient can submit to immobilization until radiographs show reconstitution of the fragment, it should be removed as soon as it is detected. MAX CLIMAN, M.D.

Osteoid Osteoma. Samuel Kleinberg. Am. J. Surg. 66: 396–401, December 1944.

Osteoid osteoma is a lesion which can usually be readily diagnosed. At times, however, its identification may present difficulties, particularly if it is so located that it does not permit accurate roentgenographic visualization or if there is an associated tissue reaction which simulates another disease.

Clinically osteoid osteoma has a triad of significant features which should suggest its presence. The first of these is localized pain, usually in an extremity, gradual in onset and later becoming persistent and continuous. The greatest intensity of the pain is always in the same location and is characteristically limited to a comparatively small area which may be surrounded by a large surface with less severe pain. Second, if the area of the lesion is accessible to physical examination, and it usually is, there is tenderness to pressure in the region of the most intense pain. Third, the roentgenogram exhibits a small round or oval rarefaction of bone at the approximate site of the pain and tenderness. The rarefied area is surrounded by a zone of sclerosis which may appear as a narrow ring or may extend for several inches beyond the central focus. These symptoms and roentgen changes are not accompanied by any systemic disturbances, and the customary laboratory tests are negative.

Three cases of osteoid osteoma are reported. The first was a typical case involving the upper metaphysis of the fibula. In the second case a diagnosis of osteodi osteoma was not made preoperatively. This patient, a ten-year-old girl, had been treated for about a year for backache, which had been attributed in turn to strain, scoliosis, and osteochondritis of the spine. Lateral roentgenograms finally showed a slight kyphos at the level of the first and second lumbar vertebrae with diminution in the size of the intervertebral disk between these vertebrae, and a diagnosis of possible early Pott's disease was entertained. When first seen by the author, the patient complained of severe pain in her back only in the region of the first and second lumbar vertebrae. In that location there was tenderness to pressure on the right side of the spinous process and nowhere else. A mild left lumbar scoliosis was present. Roentgenograms taken at this time, as well as earlier

films, showed an excavation in and absorption of part of the right lamina of the second lumbar vertebra, which had previously been overlooked. Believing that there was probably a neoplasm which was eroding the lamina, the author advised an exploratory operation. This revealed a red, granular mass the size of a cherry between the laminae of the first and second lumbar vertebrae on the right side with erosion of a part of the lamina of the second lumbar vertebra. The mass was removed and a hemilaminectomy on the first and second lumbar vertebrae was performed to allow inspection of the dura. The pathological diagnosis was osteoid osteoma. The patient was completely relieved of her backache and at the time of the report was rapidly regaining full function of the spine.

The third case, in point of difficulty in differential diagnosis, lies between the two previous cases. The osteoid in this case involved the neck of the astragalus. In the early stages of the disease there was such a marked swelling of the ankle extending up along the heel cord that a diagnosis of tuberculous arthritis was suggested. Immobilization gave no relief, and an arthrotomy did not disclose the real pathological process. The persistence of the greatest pain and tenderness in the anterior portion of the ankle in the region of the astragalus and the eventual appearance of a localized rarefaction in the neck of the astragalus led to the correct diagnosis and a surgical cure.

Roentgenograms are reproduced.

Differential Diagnosis of Ewing's Sarcoma: Contribution to the Knowledge of Primary Reticulum-Cell Sarcoma of Bone and So-Called Eosinophilic Granuloma. C. G. Ahlström and S. Welin. Acta radiol. 24: 67–81, Feb. 28, 1943. (In German.)

A case of primary reticulum-cell sarcoma of the bone and one of eosinophilic granuloma of the skeleton are reported. The roentgen differentiation of these conditions from Ewing's sarcoma may be difficult, requiring supplementary anatomic and clinical examinations. In connection with these two cases, the authors deal with the anatomic, roentgenologic, and clinical picture of the primary reticulum-cell sarcoma and of eosinophilic granuloma. The relation between the latter and Schüller-Christian disease is stressed.

MAX SGALITZER, M.D.

Syndrome of Precocious Puberty, Fibrocystic Bone Disease and Pigmentation of the Skin: Eleven Years' Observation of a Case. Bernard M. Scholder. Ann. Int. Med. 22: 105–118, January 1945.

The author's patient, a girl of nineteen at the time of this report, had been under his observation since the age of eight. She gave a history of vaginal bleeding, more or less irregular, since the age of three. Prominence of the breasts was observed in the fifth and pubic hair in the sixth year. A fracture of the humerus was sustained at the age of six, and abnormalities of the bone structure were discovered at that time.

At nine years of age, roentgen studies demonstrated multiple areas of bone absorption in the left upper and lower extremities and left ilium. The right side of the skull showed bone condensation at the base and about the right orbit. A biopsy specimen from the left humerus revealed fibrous osteitis. Calcium and phosphorus determinations were within normal limits. Studies of sex hormone in the urine disclosed an increase over the amount normally found at this age. The conclusion reached at this time was that the patient had a "complicated endocrine disease, involving the parathyroid, suprarenal cortex, and ovarian-pituitary functions." An intravenous pyelogram failed to reveal any evidence of a tumor of the adrenal cortex.

At the age of twelve the patient was given a course of injections of antuitrin-S, in order to stimulate maturation of the ovarian follicles and thus establish a more regular menstrual cycle. Roentgenograms at this time showed (1) involvement of right side of skull and left side of the torso and extremities; (2) bone condensation in the skull and bone absorption in the trunk and extremities; (3) early maturation of the skeleton, *i.e.*, closure of the epiphyses.

Intellectually the patient developed satisfactorily, her scholastic attainments being of the highest order. At the age of nineteen the most obvious external abnormalities were a slight limp, shortness of stature (61.5 in.), and facial asymmetry due to prominence of the right frontal and maxillary bones. An area of yellowish-brown pigmentation, about 4 cm. in diameter, was present over the left lumbosacral joint.

Eighteen cases similar to the one reported have been collected from the literature and are presented in tabular form. No anatomic basis for the syndrome has been demonstrated, either on surgical exploration or at autopsy. The author's assumption is that the underlying cause is a hypothalamic (pituitary)-parathyroid disturbance. Normally, at puberty the pituitary appears to be released from certain inhibiting factors, presumably through the action of the hypothalamus, and to become active, with consequent rapid bodily growth and development of sex characteristics. A premature release from these restraining factors would seem to be a reasonable explanation for the precocious puberty in the cases under discussion. What initiates this early release is not entirely clear, but cranial injuries, intracranial tumors, and encephalitis have been observed as precursors of the syndrome. In the author's case there was a history of difficult birth, and it is suggested that some injury may have occurred at that time which affected the hypothalamic region sufficiently to disturb normal control over the pituitary. As to the skeletal changes, osteitis fibrosa cystica has been produced experimentally by a long continued excess of estrogen, probably acting through the parathyroids. That there is an excess of estrogen in the cases under discussion is obvious from the precocious puberal changes.

STEPHEN N. TAGER, M.D.

Roentgenographic Interpretation of What Constitutes Adequate Reduction of Femoral Neck Fractures. Robert T. McElvenny. Surg., Gynec. & Obst. 80: 97–106, January 1945.

The author suggests standardization of what constitutes adequate reduction of intracapsular femoral neck fractures. His suggestions are the result of a six-year period of study of both successful and unsuccessful cases and their respective roentgenograms. No particular technic is advocated for internal fixation of an intracapsular fracture of the femur, but the author has found the cannulated Smith-Petersen nail particularly satisfactory because of the success achieved with it. An excellent result is considered one with (a) no pain or spasm, (b) no limp, (c) equal leg length, (d) complete range of active hip motion including full internal ro-

...ation, (*c*) no need of external aid for walking and ...imbing. On roentgenographic examination, the neck ...practically of normal length, the head is smooth with ...ormal density, the joint space is maintained, and the ...acture has healed, with unbroken lines of trabecula... on crossing the fracture site.

The method described for obtaining reduction of ...moral neck fractures is based on complete relaxation ...der an anesthetic and consists of pulling the limb ...own in external rotation and slight abduction. While ...action is maintained, gentle flexion and moving of the ...are carried out until the neck passes the head. The ...b is then internally rotated to its limit, and no re...tance should be encountered in performing this ...aneuver. The patella should face directly medially ...d the internal femoral condyle should be directly on a ...all sandbag which supports the knee. When this ...sition is attained, the limb is adducted to neutral or ...ghtly beyond. An anteroposterior and, if desired, ...ateral roentgenogram are then taken. If, in the anteroposterior view, the criteria are satis...d, a guide is inserted, a guide wire is put in and then ...teroposterior and lateral views are taken. If the ...e is centered perfectly and the hip is reduced per...ly in both views, the nail is driven home. The ...oscope is used to introduce the guide and all check... done by the operator by means of roentgenograms. ...udging of the depth of the guide wire and nail is ...by the fluoroscopist and checked again by the ...erator by means of roentgenograms. ...Anteroposterior and lateral roentgenograms check ...th the depth and position of the nail and the reduc...n. If these are satisfactory, the guide and guide wire ...withdrawn and the wound is closed.

The reduction is applicable to the operating room, ...author has found, and a flat wooden table with a ...sette box under its top proves as satisfactory as any ...le. Also he has found that the Soutter apparatus ...been most satisfactory as a method of applying ...ion.

...the standards described in this paper are based ...roentgenograms taken with the limb in full internal ...ation. In this way the length of the femoral neck ...established. Roentgenograms which are presented ...ow that the head and neck are separate from one ...other and that there are no overlapping shadows ...ere a portion of the neck covers a portion of the head. ...overlap is present, it means that complete reduction ...s not been attained, because if complete internal ro...ion be present, any overlap indicates overriding or ...ulation, but not end-to-end contact. Any x-ray ...short of complete internal rotation distorts the ...onship of the head and neck and makes interpre...tion of the film practically worthless.

A satisfactory reduction is one in which the limb is in ...mplete internal rotation and at least neutral lateral ...sition. The neck fragment should be well under and ...ell inside the head fragment as shown in the antero...sterior view. In the lateral view, the head and neck ...ould be in line with no angulation and no overlap. ...e fracture surfaces should appose one another.

...l satisfactory fixation is one in which the fixation ...erial enters the shaft of the femur at or below the ...vel of the lesser trochanter, runs through the lower ...alf of the neck parallel to the calcar femorale, and cen...rs the head in both planes. The main purpose of the ...ation, according to the author, is to act as a guide ...ich allows the head to settle on the neck in a position in which the weight thrust is directly applied to the fracture site without shearing or torsion forces being exerted on the fixation material. The position that the femoral head and neck should assume to gain this objective is one with the neck fragment well under and well inside the head fragment as shown in the anteroposterior view.

The author had 4 failures in 38 consecutive cases of subcapital or transcervical fractures. The failures occurred in hips which were imperfectly reduced; that is, the neck fragment was not placed well under and well inside the head fragment. The failures were due to many factors, as inability to obtain correct traction, inability to obtain adequate lateral roentgenograms, poor anesthesia, personal carelessness, and occasional inability to obtain satisfactory reduction of the hip under ideal conditions.

The author believes that, if a hip cannot be reduced or if there is doubt as to the effectiveness of reduction, either an immediate intertrochanteric or subtrochanteric osteotomy should be performed, as the case may require. Also, if a hip be fixed but is not doing well, an osteotomy should be done at the first signs of failure. Such a plan, he believes, might reduce the amount of disability now following intracapsular fractures of the femoral neck.

R. E. Booth, M.D.

Slipping of the Upper Femoral Epiphysis: Diagnostic and Therapeutic Considerations. William T. Green. Arch. Surg. 50: 19–32, January 1945.

If slipping of the upper femoral epiphysis is detected early, the prognosis should be excellent, but if marked displacement occurs, there may be severe crippling in spite of treatment. This report deals with 26 cases, 10 bilateral, in children from 7 to 14 years old. In 28 hips the results are known, 2 were not treated, and 6 were treated too recently for evaluation. Limitation of internal rotation is the earliest physical sign; limitation of flexion and abduction, pain, muscle spasm, and limp appear later. The hip may be capable of hyperextension.

A meticulous roentgen examination is necessary for early diagnosis. Studies must include a lateral projection (the author prefers a "frog" projection). The earliest finding is rarefaction of the neck adjacent to the epiphyseal line and minimal anterior displacement of the head; this can be seen only in a lateral view. If the first examination is normal, suggestive clinical findings should lead to repetition at short intervals. More marked displacements are readily recognized; there may be callus formation at the angle between the head and the neck.

Early cases are best treated by a combination of traction and plaster fixation; nailing *in situ* without arthrotomy gave almost as good results. Cases with severe displacement did best following arthrotomy with resection of a small section of the neck (to preserve without tension the posterior capsule for its blood supply) with subsequent reposition of the head and nailing. Closed manipulation led to poor results.

Lewis G. Jacobs, M.D.

Brachial Pain from Herniation of Cervical Intervertebral Disc. F. A. Elliott and Michael Kremer. Lancet 1: 4–8, Jan. 6, 1945.

Eight cases of brachial pain are presented. In these cases there was a uniform distribution of pain in the

back of the shoulder, down the back of the arm and the radial border of the forearm, and sometimes in the upper pectoral region. There were paresthesias in the thumb, index, and middle fingers. In some cases there was a history of acute stiff neck. Findings included limitation of movement of the neck, pain in the arm produced by movements of the neck and by downward pressure on the head, and tenderness, weakness, and wasting of the upper fibers of the pectoralis major, triceps, and extensors of the wrist and fingers. The triceps was reduced or absent, usually with hypalgesia on the thumb and index finger. The clinical picture was that of a lesion of the 7th cervical root.

Roentgenograms may be normal. There may be a reduction of the normal cervical lordosis, narrowing of the 6th cervical disk, narrowing with sclerosis of the margins of the adjacent vertebrae, narrowing with anterior lipping, and narrowing with lipping in the region of the intervertebral foramen. The last finding is probably important, inasmuch as the foramen is narrower from side to side than from above down, and any further reduction of its width by a protrusion of the disk will compress the emerging root. Lipping is best seen in the oblique views. Changes such as these are, however, at most suggestive, as they are common in persons without symptoms. More accurate information is derived from contrast myelography. Pantopaque is used for this purpose because its fluidity enables it constantly to fill small spaces like the dural sleeve and it can be removed by a lumbar puncture needle with relative ease when the examination is complete. In 3 cases in which myelography was done, a filling defect was demonstrated opposite the 6th cervical disk on the affected side and—more important—the dural sleeve surrounding the root did not fill, in contrast to good filling of the unaffected roots above and below. This obliteration of the root sac confirms the presence of a pathological process and, in conjunction with a filling defect or notch in the column of pantopaque, suggests that non-filling is due to a herniation of the disk at that level.

In none of the authors' cases was surgery considered necessary, the pain being relieved by keeping the neck at rest.

Clothespin Graft of the Spine for Spondylolisthesis and Laminal Defects. David M. Bosworth. Am. J. Surg. 67: 61–67, January 1945.

Of 77 bone grafts of the spine which have been performed at St. Luke's Hospital, New York, 11 were for spondylolisthesis, 32 for posterior herniation of the intervertebral disk, 8 for laceration of the intervertebral disk without posterior protrusion (including 2 probable cases of tuberculosis), 20 for lumbosacral strain (associated Schmorl's nodes and dural adhesions included), 1 for spinal cord tumor, 3 for old extensive laminectomy defects, and 2 for pseudarthrosis of previous spine fusion. The grafts included 66 of the double-clothespin and 8 of the single-clothespin type, 2 angulated strut grafts, and 1 inclusion graft. In the clothespin or "H" graft, which was devised by the author to overcome the structural weakness of the inclusion graft, the ends are notched to receive the spinous processes at either end of the fusion area. The graft is placed with the patient in flexion and the spinous processes separated. When the patient is extended, the graft is maintained firmly in position. Tibial bone was used at first for graft substance, but later massive iliac bone grafts were adopted.

In only 55 cases in this series had a sufficient time elapsed since operation to permit determination of solidity of the spinal fusion. Although the author feels that clinical estimation of solidity is unsatisfactory, he states that 49 of these cases (89 per cent) were believed to be solid. Four cases were known to be clinical failures. The only accurate method of determining solid spinal fusion is by flexion and extension roentgenograms. When such films are superimposed and no motion whatever is shown, a solid ankylosis can be assumed. Superimposed right and left lateral views are an additional safeguard. Forty-one of the present series were checked with motion x-rays; 33 of them (80.4 per cent) were completely solid, the films accurately superimposed and no motion could be demonstrated. In 6 (14.6) motion was demonstrable and failure of synostosis was accepted as present. Two cases (4.9 per cent) almost superimposed in the flexion and extension views and were probably solid, the slight change being accounted for by rotation of the patient in taking the films. If these are included, solid union was obtained in 88 per cent of the series.

A Case of Rupture of a Congenital Discoid Cartilage. J. R. Belcher. Brit. J. Surg. 32: 435–437, January 1945.

A case is recorded in which a tear in a congenital discoid cartilage of the left knee was demonstrated preoperatively by air arthrography according to the technic of Cullen and Chance (Brit. J. Surg. 30: 241, 1943. Abst. in Radiology 41: 413, 1943). The roentgenograms are reproduced.

Mechanical Accidents During Convulsion Therapy. Celso Pereira da Silva and Paulo Ferreira de Barros. Arq. assist. psicopat. estad. São Paulo 9: 107–127, March–June 1944.

In a period of fifty-five months, 1,843 persons underwent convulsive therapy at the Juqueri Hospital, São Paulo, Brazil. Metrazol was used to induce the convulsion in 1,500 patients and "electroshock" in 343. Twelve of the patients receiving metrazol and 3 of the electrotherapy patients sustained fractures. In addition, there was a shoulder dislocation in a patient treated by metrazol. Only cases severe enough to call for roentgen examination are included. The accidents are attributed to weakness of skeletal structures, abnormality of muscular response, and defective restraint. All of the patients made good recoveries.

In the authors' opinion a pre-convulsion roentgenogram is not indicated, as the percentage of skeletal complications is low and contraindications so detected would not outweigh the psychiatric indications for treatment.

War Casualties from Prolonged Exposure to Wet and Cold. Russel H. Patterson and Fred M. Anderson. Surg., Gynec. & Obst. 80: 1–11, January 1945.

This is a report of the authors' experiences with injuries to the feet due to exposure during the Attu campaign, from May 11 to May 28, 1943. The patients were exposed from three to fourteen days to wet and cold, with artificial heat seldom available. A marked individual susceptibility was noted. Pain and hypesthesia were the main symptoms. The degree of tissue damage could not be correlated with the duration of exposure.

Twenty-one patients were treated by mechanical respiration produced by alternating positive and nega-

e pressure on the thorax using the Terhaar respira-. This was considered superior to the pavex boot cause it improved the deep venous and lymphatic urn to the heart, thus improving capillary flow by oducing a more favorable gradient between the ar-ioles and venules, and at the same time avoided desirable local effects. The patients were also given ygen in a further effort to relieve local tissue anoxia. Among fifty-six patients with gangrene, three with gative anaerobic cultures showed multiple circum-ibed rarefied areas in the soft tissues of the feet. ese were considered to be due to separation and re-iction of dry gangrenous tissue rather than gas-rming organisms. Changes due to gas gangrene came more suddenly and were accompanied by toxic mptoms. All patients in whom gas bacillus infection s suspected received sulfa drugs, penicillin, or both, d also prophylactic x-ray treatment.

X-ray examination in most cases showed decalcifica-on of nearly all the bones of the feet except where mplete deep necrosis with loss of blood supply oc-rred and the bones appeared dense and white.

In 2 patients venous complications developed, and 2 id a recurrence of symptoms after five to nine weeks. mputations were done five to nine weeks after injury. ll patients retained a broad moist infected area at e site of demarcation. All granulating areas were epared early for skin grafting with saline. Pathologic amination of the amputated parts revealed throm-isis and recanalization of blood vessels and total de-yelinization of nerves at the level of demarcation.

In a majority of patients a foot deformity developed, sually a claw foot with varying degrees of pes planus. he great toe was pulled downward into plantar de-rmity and the intervals between all of the toes were creased, probably due to the greater damage to the itrinsic foot muscles. Deformity reached its height t four to six weeks and then tended to subside but 6 f 11 men with moderate tissue damage had persistent formity after eight to ten months.

FRANK P. BROOKS, M.D.

Studies on Diseases of Muscle: Progressive Muscu-ir Dystrophy: Clinical Review of Forty Cases. Robert . Shank, Helena Gilder, and Charles L. Hoagland. rch. Neurol. & Psychiat. 52: 431–442, December 1944.

A clinical study of 40 patients with progressive uscular dystrophy is presented with reference to sex, ge, and racial incidence. A discussion of the heredi-ary nature of the disease, its clinical course, and com-non physical signs is given. Roentgenograms are said o show streaking of the soft tissues of the affected nuscles, demineralization of bones, and delay in ssification. Metabolic studies on some of the patients —rate of urinary excretion of creatine and creatinine, reatin tolerance, basal metabolic rate, intravenous dextrose tolerance, and nitrogen and phosphorus balance—are compared with normals.

ROBERT S. MACINTYRE, M.D.
(University of Michigan)

GYNECOLOGY AND OBSTETRICS

Future of Radiology in Obstetrics. J. Blair Hartley. Brit. J. Radiol. 17: 241–246, August 1944.

The author first lists and discusses those types of in-vestigation in which radiology may be expected to yield reasonably accurate information. These are: (1) demonstration of fetal parts (at 16 weeks or over); (2) estimation of fetal maturity; (3) demonstration of fetal death; (4) presentation and position of fetus; (5) demonstration of bony pelvis (shape and inclina-tion of inlet; birth canal; outlet); (6) pelvimetry; (7) size and shape of uterus; (8) detection of fetal de-formities and grosser developmental defects; (9) pyelography (size, function, defects, etc., of the ma-ternal urinary tract). He then considers those types of examination in which normally a high degree of ac-curacy may be forthcoming, but in which it cannot be guaranteed, either because of complications or because there remain certain features still undemonstrable by any known technic. The list includes (1) early de-tection of the fetus; (2) estimation of disproportion (in spite of cephalometry and pelvimetry); (3) diagnosis of extra-uterine gestation; (4) diagnosis of complicat-ing tumors; (5) cause of non-descent of fetal head into the pelvic inlet; (6) demonstration of placental site; (7) diagnosis of post-maturity; (8) detection of minor fetal defects and deformities.

Among future developments which are desirable are a radiopaque medium for placentography, some method for outlining tumors, a method of determining sex, more knowledge about the role of heredity in skeletal defects, more knowledge about the mechanism of labor, and the estimation and significance of molding.

The latter part of the paper is devoted to a plan for obstetrical research as a part of a national health pro-gram for Great Britain. SYDNEY J. HAWLEY, M.D.

THE GENITO-URINARY SYSTEM

Radiologic Aspect of the Urologic Problem. Robert A. Arens. J. A. M. A. 126: 605–607, Nov. 4, 1944.

Tersely, with the justifiable assurance of one who has had long and valuable experience, the author sum-marizes the precautions to be observed, the essential features of good technic to be employed, and the re-sults to be expected when x-ray methods are utilized in the study of the urinary tract.

FRED JENNER HODGES, M.D.
(University of Michigan)

Congenital Solitary Kidney: Case Reports and Con-sideration of Military Significance. Thomas F. Conroy and John H. Walker. J. Urol. 53: 4–10, January 1945.

The authors believe that congenital solitary kidney is a fairly common anomaly, with an incidence of ap-proximately 1 in 1,000. Its recognition is usually in-cidental to examination for some other condition. The authors quote from Dourmashkin and Light (Am. J. Surg. 50: 348, 1940) the essential criteria for a correct diagnosis: "(1) Absence of the renal silhouette on the abdominal flat film. (2) Roentgenological evidence of renal enlargement and possible asymmetry of the psoas shadows. (3) Absence of opaque media on the agenetic side on excretory urography. (4) Absence of the ureteral orifice on one side after repeated cysto-scopic examination in an otherwise normally appearing bladder. (5) Absence of indigo carmine elimination on the affected side." A sixth and corroborative criterion is the presence of an associated abnormality of the geni-tal tract. Such abnormalities are more frequent and of greater clinical significance in the female.

In spite of these very definite criteria, mistakes in diagnosis are possible. Renal ischemia resulting from shock may cause temporary loss of renal function, and

back of the shoulder, down the back of the arm and the radial border of the forearm, and sometimes in the upper pectoral region. There were paresthesias in the thumb, index, and middle fingers. In some cases there was a history of acute stiff neck. Findings included limitation of movement of the neck, pain in the arm produced by movements of the neck and by downward pressure on the head, and tenderness, weakness, and wasting of the upper fibers of the pectoralis major, triceps, and extensors of the wrist and fingers. The triceps was reduced or absent, usually with hypalgesia on the thumb and index finger. The clinical picture was that of a lesion of the 7th cervical root.

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THE BLOOD VESSELS

Method for Visualizing the Blood Vessels of Nerves ıd Other Tissues. Joseph Epstein. Anat. Rec. 89: ı-69, May 1944.

In roentgenography of the fine vascular structure of ı organ, the injection mass employed must fill and ıarply define the vessels in a uniform manner. The ıthor has found that a mixture of red lead in glue elds more satisfactory results than the commonly ıed preparations such as barium sulfate in gelatin, ırium sulfate in agar, red lead in gelatin, and red lead agar. The injected arteries can also be studied after ıe specimen has been cleared by the Spalteholz chnic. This method, at first used to study the blood ıssels of the sciatic nerve in dogs, has subsequently roved useful in defining the vascular supply of other ssues. The technic of preparing and injecting the ıedium and of taking the roentgenograms is de- ıribed.

TECHNIC

Volume Localisation of Deep-Seated Tumours by Means of Tomography. E. M. Ungar, G. Spiegler, and D. W. Smithers. Brit. J. Radiol. 17: 235–238, August 1944.

The growing use of volume doses makes the knowledge of the volume of a tumor and its localization imperative. This is best determined by tomography whenever the tumor may be visualized. It is particularly useful in tumors of the nasal sinuses, pharynx, larynx, lungs, fundus of the stomach, and the bladder.

For treatment purposes it is necessary to know the exact size. It is therefore necessary to know the exact depth at which the tomogram is made. This is accomplished by using a scale beside the patient, made of wax with opaque numerals indicating the depth at centimeter intervals. With this information and the target-film distance, correction can be made for distortion at any level. SYDNEY J. HAWLEY, M.D.

RADIOTHERAPY

Team Work in the Treatment of Cancer. The Mackenzie Davidson Lecture. H. S. Souttar. Brit. J. Radiol. 17: 229–234, August 1944.

After a brief tribute to Sir James Mackenzie Davidson, one of the pioneers of British radiology, the author considers how best the resources of medicine may be organized for the treatment of cancer. The surgeon was the first to make a scientific attack on the disease. With the advent of x-rays and radium, the physicist opened up new prospects of cure, and recently the chemist has entered the field with stilbestrol and other preparations. The future rests with team work on the part of all these. While there will be no sharp boundaries defining the limits within which the activities of each worker must be confined, there must necessarily be spheres in which each is predominant. The attitude should be how much can each specialist contribute; not how much can he extend the value of his specialty.

The surgeon should establish the diagnosis, with the aid of biopsy whenever possible, and determine the extent of the tumor and the stage which it has reached, as well as forming a clear idea of the possibility and dangers of surgical removal. In therapy, some fields are notably the province of surgery, as cancer of the stomach and cancer of the colon; others belong to the radiologist, as cancer of the cervix. In still other cases the field is not well defined. It is here that team work will yield the best results. In some cases the surgeon can be of assistance to the radiologist by exposing the tumor or by removing residuals after treatment is completed.

Both the surgeon and the radiologist are indebted to the physicist, and he should be included to insure a good team, as should a biological chemist.

SYDNEY J. HAWLEY, M.D.

On Neglects from Patients and Doctors as to Symptoms and Diagnosis in Uterine Cancer. Lars Edling. Acta radiol. 24: 45–54, Feb. 28, 1943. (In English.)

A critical survey of the cases of cancer of the uterine cervix seen at King Gustav V's Jubilee Clinic in Lund from 1927 to 1936 (414 cases with a 5-year cure of 26.2 per cent) shows that, at the original admission to the clinic, this disease is generally much more advanced than one would suppose from the history as given by the patients. In most cases this is due to their own lack of attention to their symptoms, usually as a result of indifference or ignorance. Not seldom, however, the doctor consulted is to blame for a false diagnosis or for failure to make a thorough examination. The blame lay here in 9 per cent of the series reported.

The author has grouped his material according to the time elapsed from the onset of cancer symptoms until the first medical consultation. He gives a detailed account of the special symptoms accompanying the different stages of the disease, as well as his impressions regarding the influence of the mentioned "neglects" on the result of x-ray treatment.

MAX SGALITZER, M.D.

"Supervoltage" Roentgen Installation in the Antoni van Leeuwenhoekhuis: Preliminary Clinical Results. D. den Hoed. Acta radiol. 24: 82–88, Feb. 28, 1943. (In English.)

This is the fifth of a series of communications on the supervoltage [850 kv.] roentgen installation in the Antoni van Leeuwenhoekhuis, Amsterdam. The earlier papers, which dealt with the construction of the apparatus and physical and biological observations made with it (Acta radiol. 21: 62, 583, 591, 1940; 23: 565, 1942), are briefly summarized. Here the author records the first year's clinical experience, though he recognizes that after so short an interval—two and a half years—no final conclusions can be drawn. Results, however, were encouraging in some groups of patients, especially those with far-advanced cancer of the uterine cervix. Of 23 patients with cervical carcinoma regarded as incurable, 5 were "provisionally cured" (one and a half to two and a half years). Favorable palliative effects were obtained in other cases and reactions were moderate. MAX SGALITZER, M.D.

An Evaluation of Radiation in the Treatment of Carcinoma of the Corpus Uteri. James A. Corscaden. J. A. M. A. *126*: 1134–1138, Dec. 30, 1944.

The author presents an evaluation of the role of radiation in the treatment of carcinoma of the corpus uteri. The data for this analysis are largely derived

from reports in the literature, but some new observations based on his own experience are included. Considering only "operable" cases, the author presents evidence to show that with adequate doses of radium alone (intrauterine application), about 50 per cent five-year survivals may be expected. In the same type of case, surgery (total hysterectomy and bilateral salpingo-oophorectomy) without irradiation should produce somewhere near 60 per cent five-year survivals. It is the author's belief that the existing evidence justifies the expectation of 80 per cent five-year survivals in "operable" cases when the combination of preoperative x-ray and radium therapy, in adequate dosage, is followed by total hysterectomy.

ROBERT S. MACINTYRE
(University of Michigan)

Embryonal Tumor of the Sympathetic Nervous System: Report of Two Cases. Eric Selander. Acta radiol. 24: 1–12, Feb. 28, 1943. (In English.)

Embryonal tumors of the sympathetic nervous system are rare malignant growths. They occur usually in children and metastasize early to bones, lymph nodes, and liver.

They arise from the common mother cells of the sympathetic ganglion cells and the chromaffin system, namely the sympathogonia, which in size and appearance are similar to lymphocytes, or they may be derived from cells which already show some differentiation. They usually occur in the ganglionated cord or the adrenal medulla.

An early diagnosis is difficult or impossible, and metastases are often the first clinically demonstrable lesions. Microscopic diagnosis of the tumor is also difficult, since its cells may often be mistaken for those of a small-cell sarcoma.

Both primary tumor and metastases are very sensitive to x-rays. The therapeutic effect is temporary, however, as in most cases the treatment will not be started until metastases have already spread over the body.

MAX SGALITZER, M.D.

Radiotherapy in Osteoclastoma. Gwen Hilton. Lancet 1: 110–112, Jan. 27, 1945.

Some authorities believe that osteoclastomas are of two roentgenologic types—the trabeculated and the osteolytic. Others regard the osteolytic type as only a more advanced form of the trabeculated. Three cases of the osteolytic stage or type are here presented, illustrating the difficulty of differential diagnosis. Two of the tumors were in the lower end of the femur, and one in the lower end of the radius. These are common sites for osteoclastomas of either type, and both the epiphysis and metaphysis are usually involved. Two of the cases showed the periosteal lipping generally considered pathognomonic of sarcoma. A biopsy was done in one of these cases, however, showing osteoclastoma and proving that lipping may be seen in such tumors also. While both sarcoma and osteoclastoma may show a central destructive lesion with a peripheral osteogenesis (periosteal lipping), the character of the tumor margin on the shaft side often differs. In a sarcoma the adjacent bone has an irregular appearance, which has been described as moth-eaten; whereas in osteoclastoma it may be foam-like, or the density of the shaft may gradually diminish toward the tumor area, or there may be a faint clear-cut trabeculation. When biopsy is impossible, the response of the neoplasm to irradiation may clarify the diagnosis. About twelve weeks after treatment of an osteoclastoma (as demonstrated in the author's cases), roentgenograms show early calcification. This recalcification proceeds and trabeculation reappears in the rarefied area. The trabeculae are, however, less clear-cut than in an untreated case, and the loculi between the strands are somewhat hazy. In sarcoma and in metastatic deposits, recalcification does not usually show honeycomb formation.

Satisfactory results with roentgen therapy were obtained in all three of the author's cases of osteolytic osteoclastoma. Cases of the trabeculated type have shown an equally good response, with no recurrences. Roentgenograms are reproduced.

Air Absorption Corrections for Soft X Rays. C. E. Eddy and J. L. Farrant. Brit. J. Radiol. 17: 278–279, September 1944.

Absorption by air introduces an appreciable error in the measurement of x-ray dosage with soft radiation. The amount of this error was determined by various methods and is presented in a curve which shows the greatest error to be about 3 per cent at the h.v.l. of 0.5 mm. Al (50 to 60 kv.) to less than 0.5 per cent for 6.0 mm. Al (140 kv.).

SYDNEY J. HAWLEY, M.D.

RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

Vol. 45 NOVEMBER 1945 No. 5

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RADIOLOGY

A MONTHLY PUBLICATION DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

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As a convenience to contributors to RADIOLOGY who are unable to supply prints for their manuscripts, the Editor can arrange for intermediate prints from roentgenograms.

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Strange Repercussions of Röntgen's Discovery of the X-Rays

OTTO GLASSER, Ph.D.

Research Division, Cleveland Clinic, Cleveland, Ohio

In events that followed the discovery of the x-rays in 1895 and in their discoverer's reaction to these events is material for a psychological study of the effect on Wilhelm Conrad Röntgen of public acclaim and criticism. It is interesting that Röntgen assiduously avoided exposing himself to acclaim and reacted in an almost exaggerated manner to criticism.

At the time of the discovery of the x-rays, physicists complacently accepted the fact that there was little new to be discovered in physical science and accordingly strove mostly to attain greater accuracy in physical mensuration. For no obvious reason Röntgen was an exception. In March 1895, he was fifty years of age and well situated as professor of physics at the Julius-Maximilian's University in Würzburg. Forty-eight papers published in the previous twenty-five years attested to the originality of his findings in physical research. His report of the electrodynamic effects of a dielectric moved through a homogeneous electrical field, for example, had so impressed his colleagues that they suggested calling the current thus produced the "roentgen current." In the academic world he had a record of similarly satisfactory achievement, and the previous year he had been elected to the highest office of the university, that of rector. Yet with youthful enthusiasm, late in 1895, he turned his full attention to researches on the cathode rays, along the lines laid down by Hittorf and Crookes and by Hertz and Lenard.

The systematic reproduction of previous cathode-ray experiments and the subsequent tracing of the fluorescent effect produced by something emanating from an excited Hittorf-Crookes tube led to the discovery of a new kind of rays, the x-rays. The analysis of this new effect and the investigation of all its ramifications as reported in his three classic papers on *A New Kind of Rays* (1) reveal Röntgen to be one of the greatest scientists of all time. He was immediately and widely acclaimed. Yet almost simultaneously voices of criticism were heard. With a certain bravado, Röntgen wrote to his good friend Zehnder (2) shortly after the announcement of the discovery:

> "My work has received recognition from many quarters. . . . This is worth a great deal to me, and I let the envious chatter in peace; I am not concerned about that."

Doubtless because of the rapidity with which the news of the discovery was spread and the sensational manner in which most of the early reports were presented, Röntgen suffered in adjusting to the publicity, which, as it soon became evident, he wished to avoid (3). Only a few of the honors traditionally awarded to distinguished men did he care to receive personally; one of these was the first

Nobel prize ever awarded in physics, for which he traveled to Stockholm in 1901. Even this was but a half measure, in that he refused to give a Nobel lecture. His first lecture on the x-rays, delivered at the earnest request of his colleagues at the Physical Medical Society of Würzburg on Jan. 23, 1896, was probably the only public lecture he ever gave on his great discovery.

Early claims to priority in the discovery of the x-rays were partly activated by the bringing to light of certain uninvestigated accidents caused by the rays. Sir William Crookes, whose cathode-ray type tubes Röntgen had used in many of his experiments, had observed that unopened boxes of photographic plates were fogged and had complained repeatedly to the manufacturer of their unsatisfactory quality. That this effect was actually due to x-rays he did not know until Röntgen's discovery had been announced. Others had had similar experiences with x-ray plates but had only drawn the conclusion that it was advisable to store the plates some distance from the tubes (3).

Many early cathode-ray workers, as Lenard once stated (4), had observed a great number of new phenomena, but these phenomena were never followed up. The Philadelphia physicist Goodspeed had accidently made an x-ray picture over five years before the x-rays were discovered (3) and was unable to explain the phenomenon until Röntgen's observations were reported.

Although most scientists gave Röntgen full credit and the honor that were his due, a whispering campaign was started that the discovery was an accident and that the first crucial observation of the fluorescence of the screen was made by an assistant or a *Diener*. The best answer to these rumor mongers was given by Münsterberg of Harvard, who in reporting his views on the discovery to *Science* on Jan. 15, 1896, wrote:

"Suppose chance helped. There were many galvanic effects in the world before Galvani saw by chance the contraction of a frog's leg on an iron gate. The world is always full of such chances, and only the Galvanis and Röntgens are few."

Still, the silly rumors persisted throughout Röntgen's life. With advancing years he retired behind a protective screen and eventually became very bitter. Two far reaching effects of his bitterness were his refusal to publish anything further on the rays after his three original communications and the stipulation in his will that all records of his work and all correspondence about the discovery between 1895 and 1900 be burned unopened at his death, a decision which—unfortunately—had to be carried out to the letter. There is no doubt that vicious attacks which appeared from time to time—an especially violent one was published in the *Münchner Post* in 1908—were responsible for these decisions. A few years before his death, in April 1921, Röntgen expressed his feelings to his old friend and collaborator Zehnder, in the following words:

"The infamous rumor that I did not discover the rays originated presumably in Quincke's institute in Heidelberg. . . . "

And at the same time he wrote to the wife of his late best friend, Theodore Boveri:

"Zehnder also heard the fable that I was not the first to notice the x-rays, but that an assistant or *Diener* discovered them. What miserable envious soul must have invented this story?"

Years later the slandering rumors had not died down. In 1935, twelve years after Röntgen's death, an entirely uncalled-for article appeared in the *Zürcher Illustrierte*, a Swiss weekly. The article, by one E. Grieder, entitled *The Real Facts of the Discovery of the X-Rays*, was not only slandering but full of historical inaccuracies.

After a careful scrutiny of the history of the x-rays' discovery there seems to be absolutely no justification for doubting Röntgen's original merit. It was, of course, not unnatural that Röntgen's masterful interpretation of the effect of an unknown energy source should be envied by those who had reached the threshold

of the discovery but had failed to go beyond. The world gave Röntgen its acclaim and acknowledged his discovery as one of the greatest in many decades. Today, at the semicentennial of radiology, the greatness of his discovery is recognized with gratitude by all those who have derived untold benefits from the roentgen rays in war and peace.

Cleveland Clinic
Cleveland 6, Ohio

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1895  1945

On a New Kind of Rays

WILHELM CONRAD RÖNTGEN

Radiology reprints here translations of Röntgen's original papers on the newly discovered x-rays, appearing in the Sitzungsberichte of the Würzburg Physical Medical Society on Dec. 28, 1895, and March 9, 1896. For these translations (by Arthur Stanton), it is indebted to Science, in which the first was reprinted from Nature on Feb. 14, 1896, and the second, from Electricity (London), on May 15, 1896.

1. A discharge from a large induction coil is passed through a Hittorf's vacuum tube, or through a well-exhausted Crookes' or Lenard's tube. The tube is surrounded by a fairly close-fitting shield of black paper; it is then possible to see, in a completely darkened room, that paper covered on one side with barium platinocyanide lights up with brilliant fluorescence when brought into the neighborhood of the tube, whether the painted side or the other be turned towards the tube. The fluorescence is still visible at two metres distance. It is easy to show that the origin of the fluorescence lies within the vacuum tube.

2. It is seen, therefore, that some agent is capable of penetrating black cardboard which is quite opaque to ultra-violet light, sunlight or arc-light. It is therefore of interest to investigate how far other bodies can be penetrated by the same agent. It is readily shown that all bodies possess this same transparency, but in very varying degrees. For example, paper is very transparent; the fluorescent screen will light up when placed behind a book of a thousand pages; printer's ink offers no marked resistence. Similarly the fluorescence shows behind two packs of cards; a single card does not visibly diminish the brilliancy of the light. So, again, a single thickness of tinfoil hardly casts a shadow on the screen; several have to be superposed to produce a marked effect. Thick blocks of wood are still transparent. Boards of pine two or three centimetres thick absorb only very little. A piece of sheet aluminium, 15 mm. thick, still allowed the X-rays (as I will call the rays, for the sake of brevity) to pass, but greatly reduced the fluorescence. Glass plates of similar thickness behave similarly; lead glass is, however, much more opaque than glass free from lead. Ebonite several centimetres thick is transparent. If the hand be held before the fluorescent screen, the shadow shows the bones darkly, with only faint outlines of the surrounding tissues.

Water and several other fluids are very transparent. Hydrogen is not markedly more permeable than air. Plates of copper, silver, lead, gold and platinum also allow the rays to pass, but only when the metal is thin. Platinum .2 mm. thick allows some rays to pass; silver and copper are more transparent. Lead 1.5 mm. thick is practically opaque. If a square rod of wood 20 mm. in the side be painted on one face with white lead it casts little shadow when it is so turned that the painted face is parallel to the X-rays, but a strong shadow if the rays have to pass through the painted side. The salts of the metal, either solid or in solution, behave generally as the metals themselves.

3. The preceding experiments lead to the conclusion that the density of the bodies is the property whose variation mainly affects their permeability. At least no other property seems so marked in this connection. But that the density alone does not determine the transparency is shown by an experiment wherein plates of similar thickness of Iceland spar, glass, aluminium and quartz were employed as screens. Then the Iceland spar showed itself much less transparent than the other bodies, though of approximately the same density. I have not remarked any strong fluorescence of Iceland spar compared with glass (see below, No. 4).

4. Increasing thickness increases the

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frühere Mitglieder der Gesellschaft lediglich deshalb nicht mehr im Personalverzeichnisse geführt würden, weil sie bei ihrem Weggange aus Würzburg vergessen hatten, den entsprechenden Antrag zu stellen.

Herr von Kölliker stellt deshalb einen Antrag auf diesbezügliche Aenderung der Statuten. — Ueber denselben soll in der ersten Sitzung des nächsten Geschäftsjahres berathen werden.

Am 28. Dezember wurde als Beitrag eingereicht:

W. C. Röntgen: Ueber eine neue Art von Strahlen.

(Vorläufige Mittheilung.)

1. Lässt man durch eine *Hittorf*'sche Vacuumröhre, oder einen genügend evacuirten *Lenard*'schen, *Crookes*'schen oder ähnlichen Apparat die Entladungen eines grösseren *Ruhmkorff*'s gehen und bedeckt die Röhre mit einem ziemlich eng anliegenden Mantel aus dünnem, schwarzem Carton, so sieht man in dem vollständig verdunkelten Zimmer einen in die Nähe des Apparates gebrachten, mit Bariumplatincyanür angestrichenen Papierschirm bei jeder Entladung hell aufleuchten, fluoresciren, gleichgültig ob die angestrichene oder die andere Seite des Schirmes dem Entladungsapparat zugewendet ist. Die Fluorescenz ist noch in 2 m Entfernung vom Apparat bemerkbar.

Man überzeugt sich leicht, dass die Ursache der Fluorescenz vom Entladungsapparat und von keiner anderen Stelle der Leitung ausgeht.

2. Das an dieser Erscheinung zunächst Auffallende ist, dass durch die schwarze Cartonhülse, welche keine sichtbaren oder ultravioletten Strahlen des Sonnen- oder des elektrischen Bogenlichtes durchlässt, ein Agens hindurchgeht, das im Stande ist, lebhafte Fluorescenz zu erzeugen, und man wird deshalb wohl zuerst untersuchen, ob auch andere Körper diese Eigenschaft besitzen.

Man findet bald, dass alle Körper für dasselbe durchlässig sind, aber in sehr verschiedenem Grade. Einige Beispiele führe ich an. Papier ist sehr durchlässig:[1]) hinter einem eingebun-

[1]) Mit „Durchlässigkeit" eines Körpers bezeichne ich das Verhältniss der Helligkeit eines dicht hinter dem Körper gehaltenen Fluorescenzschirmes zu derjenigen Helligkeit des Schirmes, welcher dieser unter denselben Verhältnissen aber ohne Zwischenschaltung des Körpers zeigt.

Reproduction of the opening paragraphs of Röntgen's first communication on the x-rays, as originally published.

hindrance offered to the rays by all bodies. A picture has been impressed on a photographic plate of a number of superposed layers of tinfoil, like steps, presenting thus a regularly increasing thickness. This is to be submitted to photometric processes when a suitable instrument is available.

5. Pieces of platinum, lead, zinc, and aluminium foil were so arranged as to produce the same weakening of the effect. The annexed table shows the relative thickness and density of the equivalent sheets of metal.

	Thickness	Relative thickness	Density
Platinum	0.018 mm.	1	21.5
Lead	0.050 mm.	3	11.3
Zinc	0.100 mm.	6	7.1
Aluminium	3.500 mm.	200	2.6

From these values it is clear that in no case can we obtain the transparency of a body from the product of its density and thickness. The transparency increases much more rapidly than the product decreases.

6. The fluorescence of barium platinocyanide is not the only noticeable action of the X-rays. It is to be observed that other bodies exhibit fluorescence, *e. g.*, calcium sulphide, uranium glass, Iceland spar, rock salt, etc.

Of special interest in this connection is the fact that photographic dry plates are sensitive to the X-rays. It is thus possible to exhibit the phenomena so as to exclude the danger of error. I have thus confirmed many observations originally made by eye observation with the fluorescent screen. Here the power of the X-rays to pass through wood or cardboard becomes useful. The photographic plate can be exposed to the action without removal of the shutter of the dark slide or other protecting case, so that the experiment need not be conducted in darkness. Manifestly, unexposed plates must not be left in their box near the vacuum tube.

It seems now questionable whether the impression on the plate is a direct effect of the X-rays, or a secondary result induced by the fluorescence of the material of the plate. Films can receive the impression as well as ordinary dry plates.

I have not been able to show experimentally that the X-rays give rise to any calorific effects. These, however, may be assumed, for the phenomena of fluorescence show that the X-rays are capable of transformation. It is also certain that all the X-rays falling on a body do not leave it as such.

The retina of the eye is quite insensitive to these rays; the eye placed close to the apparatus sees nothing. It is clear from the experiments that this is not due to want of permeability on the part of the structures of the eye.

7. After my experiments on the transparency of increasing thicknesses of different media, I proceeded to investigate whether the X-rays could be deflected by a prism. Investigations with water and carbon bisulphide in mica prisms of 30° showed no deviation either on the photographic or the fluorescent plate. For comparison, light rays were allowed to fall on the prism as the apparatus was set up for the experiment. They were deviated 10 mm. and 20 mm. respectively in the case of the two prisms.

With prisms of ebonite and aluminium I have obtained images on the photographic plate which point to a possible deviation. It is, however, uncertain, and at most would point to a refractive index 1.05. No deviation can be observed by means of the fluorescent screen. Investigations with the heavier metals have not as yet led to any result, because of their small transparency and the consequent enfeebling of the transmitted rays.

On account of the importance of the question it is desirable to try in other ways whether the X-rays are susceptible of refraction. Finely-powdered bodies allow in thick layers but little of the incident light to pass through, in consequence of refraction and reflection. In the case of the X-rays, however, such layers of powder are for equal masses of substance equally transparent with the coherent solid itself. Hence

we cannot conclude any regular reflection or refraction of the X-rays. The research was conducted by the aid of finely-powdered rock salt, fine electrolytic silver powder, and zinc dust, already many times employed in chemical work. In all these cases the result, whether by the fluorescent screen or the photographic method, indicated no difference in transparency between the powder and the coherent solid.

It is, hence, obvious that lenses cannot be looked upon as capable of concentrating the X-rays; in effect, both an ebonite and glass lens of large size prove to be without action. The shadow photograph of a round rod is darker in the middle than at the edge; the image of a cylinder filled with a body more transparent than its walls exhibits the middle brighter than the edge.

8. The preceding experiments, and others which I pass over, point to the rays being incapable of regular reflection. It is, however, well to detail an observation which at first sight seemed to lead to an opposite conclusion.

I exposed a plate, protected by a black paper sheath, to the X-rays, so that the glass side lay next to the vacuum tube. The sensitive film was partly covered with star-shaped pieces of platinum, lead, zinc and aluminium. On the developed negative the star-shaped impression showed dark under platinum, lead, and, more markedly, under zinc; the aluminium gave no image. It seems, therefore, that these three metals can reflect the X-rays; as, however, another explanation is possible, I repeated the experiment with this only difference, that a film of thin aluminium foil was interposed between the sensitive film and the metal stars. Such an aluminium plate is opaque to ultraviolet rays, but transparent to X-rays. In the result the images appeared as before, this pointing still to the existence of reflection at metal surfaces.

If one considers this observation in connection with others, namely, on the transparency of powders, and on the state of the surface not being effective in altering the passage of the x-rays through a body, it leads to the probable conclusion that regular reflection does not exist, but that bodies behave to the X-rays as turbid media to light.

Since I have obtained no evidence of refraction at the surface of different media, it seems probable that the X-rays move with the same velocity in all bodies, and in a medium which penetrates everything, and in which the molecules of bodies are embedded. The molecules obstruct the X-rays the more effectively as the density of the body concerned is greater.

9. It seemed possible that the geometrical arrangement of the molecules might affect the action of a body upon the X-rays, so that, for example, Iceland spar might exhibit different phenomena according to the relation of the surface of the plate to the axis of the crystal. Experiments with quartz and Iceland spar on this point lead to a negative result.

10. It is known that Lenard in his investigations on cathode rays has shown that they belong to the ether and can pass through all bodies. Concerning the X-rays the same may be said.

In his latest work Lenard has investigated the absorption coefficients of various bodies for the cathode rays, including air at atmospheric pressure, which gives 4.10, 3.40, 3.10 for 1 cm., according to the degree of exhaustion of the gas in discharge tube. To judge from nature of the discharge, I have worked at about the same pressure, but occasionally at greater or smaller pressures. I find using a Weber's photometer that the intensity of the fluorescent light varies nearly as the inverse square of the distance between screen and discharge tube. This result is obtained from three very consistent sets of observations at distances of 100 and 200 mm.; hence air absorbs the X-rays much less than the cathode rays. This result is in complete agreement with the previously described result, that the fluorescence of the screen can be still observed at 2 metres from the vacuum tube. In general other bodies behave like air; they are more transparent for the X-rays than for the cathode rays.

11. A further distinction, and a noteworthy one, results from the action of a magnet. I have not succeeded in observing any deviation of the X-rays even in very strong magnetic fields.

The deviation of cathode rays by the magnet is one of their peculiar characteristics; it has been observed by Hertz and Lenard that several kinds of cathode rays exist, which differ by their power of exciting phosphorescence, their susceptibility of absorption and their deviation by the magnet; but a notable deviation has been observed in all cases which have yet been investigated, and I think that such deviation affords a characteristic not to be set aside lightly.

12. As the result of many researches, it appears that the place of most brilliant phosphorescence of the walls of the discharge tube is the chief seat whence the X-rays originate and spread in all directions; that is, the X-rays proceed from the front where cathode rays strike the glass. If one deviates the cathode rays within the tube by means of a magnet, it is seen that the X-rays proceed from a new point, *i. e.*, again from the end of the cathode rays.

Also for this reason the X-rays which are not deflected by a magnet cannot be regarded as cathode rays which have passed through the glass, for that passage cannot, according to Lenard, be the cause of the different deflection of the X-rays. Hence, I concluded that the rays are not identical with the cathode rays, but are produced from the cathode rays at the glass surface of the tube.

13. The rays are generated not only in glass. I have obtained them in an apparatus closed by an aluminium plate 2 mm. thick. I propose later to investigate the behavior of other substances.

14. The justification of the term "rays," applied to the phenomena, lies partly in the regular shadow pictures produced by the interposition of a more or less permeable body between the source and a photographic plate or fluorescent screen.

I have observed and photographed many such shadow pictures. Thus, I have an outline of part of a door covered with lead paint; the image was produced by placing the discharge tube on one side of the door, and the sensitive plate on the other. I have also a shadow of the bones of the hand; of a wire wound upon a bobbin; of a set of weights in a box; of a compass card and needle completely enclosed in a metal case; of a piece of metal where the X-rays show the want of homogeneity, and of other things.

For the rectilinear propagation of the rays I have a pin-hole photograph of the discharge apparatus covered with black paper. It is faint, but unmistakable.

15. I have sought for interference effects of the X-rays, but, possibly in consequence of their small intensity, without result.

16. Researches to investigate whether electrostatic forces act on the X-rays are begun, but not yet concluded.

17. If one asks, what then are these X-rays; since they are not cathode rays, one might suppose, from their power of exciting fluorescence and chemical action, them to be due to ultra-violet light. In opposition to this view a weighty set of considerations presents itself. If X-rays be indeed ultra-violet light, then that light must possess the following properties.

(*a*) It is not refracted in passing from air into water, carbon bisulphide, aluminium, rock salt, glass or zinc.

(*b*) It is incapable of regular reflection at the surfaces of the above bodies.

(*c*) It cannot be polarized by any ordinary polarizing media.

(*d*) The absorption by various bodies must depend chiefly on their density.

That is to say, these ultra-violet rays must behave quite differently from the visible, infra-red, and hitherto known ultra-violet rays.

These things appear so unlikely that I have sought for another hypothesis.

A kind of relationship between the new rays and light rays appears to exist; at least the formation of shadows, fluorescence, and the production of chemical action point in this direction. Now it has

een known for a long time that, besides he transverse vibrations which account for he phenomena of light, it is possible that ongitudinal vibrations should exist in the ther, and according to the view of some hysicists must exist. It is granted that heir existence has not yet been made ear, and their properties are not experi- entally demonstrated. Should not the new rays be ascribed to longitudinal waves in the ether?

I must confess that I have in the course of this research made myself more and more familiar with this thought, and venture to put the opinion forward, while I am quite conscious that the hypothesis advanced still requires a more solid foundation.

Second Communication

As my investigations will have to be nterrupted for several weeks, I propose in e following paper to communicate a few ew results.

§ 18. At the time of my first commu- ication it was known to me that X-rays ere able to discharge electrified bodies, nd I suspected that it was X-rays, not the naltered cathode rays, which got through is aluminum window, that Lenard had to o with in connection with distant electri- ed bodies. When I published my re- earches, however, I decided to wait until I ould communicate unexceptionable re- lts. Such are only obtainable when one akes the observation in a space which is ot only completely protected against the lectrostatic influences of the vacuum ube, leading-in wires, induction coil, etc., ut which is also protected against the ir coming from the vicinity of the dis- harge apparatus. To this end I made a ox of soldered sheet zinc large enough to eceive me and the necessary apparatus, nd which, even to an opening which could e closed by a zinc door, was quite air- ight. The wall opposite the door was al- most covered with lead. Near one of the discharge apparatus placed outside, the lead-covered zinc wall was provided with a slot 4 cm. wide, and the opening was then hermetically closed with a thin aluminum sheet. Through this window the X-rays could come into the observation box. I have observed the following phenomena:

(*a*) Positively or negatively electrified bodies in air are discharged when placed in the path of X-rays, and the more quickly the more powerful the rays. The intensity of the rays was estimated by their effect on a fluorescent screen or on a photographic plate. It is the same whether the electrified bodies are conductors or insulators. Up to the present I have discovered no specific difference in the behavior of different bodies with regard to the rate of discharge, and the same remark applies to the behavior of positive and negative electricity. Nevertheless, it is not impossible that small differences exist.

(*b*) If an electrical conductor is surrounded by a solid insulator, such as paraffin, instead of by air, the radiation acts as if the insulating envelope were swept by a flame connected to earth.

(*c*) If this insulating envelope is closely surrounded by a conductor connected to earth, which should like the insulator be transparent to X-rays, the radiation, with the means at my disposal, apparently no longer acts on the inner electrified conductor.

(*d*) The observations described in *a*, *b* and *c* tend to show that air traversed by X-rays possesses the property of discharging electrified bodies with which it comes in contact.

(*e*) If this be really the case, and if, further, the air retains this property for some time after the X-rays have been extinguished, it must be possible to discharge electrified bodies by such air, although the bodies themselves are not in the path of the rays.

It is possible to convince oneself in various ways that this actually happens. I will describe one arrangement, perhaps not the simplest possible. I employed a brass tube 3 cm. in diameter and 45 cm. long. A few centimeters from one end a portion of the tube was cut away and replaced by a thin sheet of aluminum. At the other end an insulated brass ball fastened to a metal rod was led into the tube through an air-tight gland. Between the ball and the closed end of the tube a side tube was soldered on, which could be placed in communication with an aspirator. When the aspirator was worked the brass ball was surrounded by air, which on its way through the tube went past the aluminum window. The distance from the window to the ball was over 20 cm. I arranged the tube in the zinc box in such a manner that the X-rays passed through the aluminum window at right angles to the axis of the tube, so that the insulated ball was beyond the reach of the rays in the shadow. The tube and the zinc box were connected together; the ball was connected to a Hankel electroscope. It was seen that a charge (positive or negative) communicated to the ball was not affected by the X-rays so long as the air in the tube was at rest, but that the charge immediately diminished considerably when the aspirator caused the air traversed by the rays to stream past the ball. If the ball by being connected to accumulators was kept at a constant potential, and if air which had been traversed by the rays was sucked through the tube, an electric current was started as if the ball had been connected with the wall of the tube by a bad conductor.

(*f*) It may be asked in what way the air loses this property communicated to it by the X-rays. Whether it loses it as time goes on, without coming into contact with other bodies, is still doubtful. It is quite certain, on the other hand, that a short disturbance of the air by a body of large surface, which need not be electrified, can render the air inoperative. If one pushes, for example, a sufficiently thick plug of cotton wool so far into the tube that the air which has been traversed by the rays must stream through the cotton wool before it reaches the ball, the charge of the ball remains unchanged when suction is commenced. If the plug is placed exactly in front of the aluminum window the result is the same as if there were no cotton wool, a proof that dust particles are not the cause of the observed discharge. Wire gauze acts in the same way as cotton wool, but the meshes must be very small and several layers must be placed one over the other if we want the air to be active. If the nets are not connected to earth, as heretofore, but connected to a constant-potential source of electricity, I have always observed what I expected; however, these investigations are not concluded.

(*g*) If the electrified bodies are placed in dry hydrogen instead of air they are equally well discharged. The discharge in hydrogen seems to me somewhat slower. This observation is not, however, very reliable on account of the difficulty of securing equally powerful X-rays in successive experiments. The method of filling the apparatus with hydrogen precluded the possibility of the thin layer of air which clings to the surface of the bodies at the commencement playing an appreciable part in connection with the discharge.

(*h*) In highly-exhausted vessels the discharge of a body in the path of the X-rays takes place far more slowly—in one case it was, for instance, 70 times more slowly—than in the same vessels when filled with air or hydrogen at atmospheric pressure.

(*i*) Experiments on the behavior of a mixture of chlorine and hydrogen, when under the influence of the X-rays, have been commenced.

(*j*) Finally, I should like to mention that the results of the investigations on the discharging property of the X-rays, in which the influence of the surrounding gases was not taken into account, should be for the most part accepted with reserve.

§ 19. In many cases it is of advantage to put in circuit between the X-ray producer and the Ruhmkorff coil a Tesla condenser and transformer. This arrange-

ment has the following advantages: firstly, the discharge apparatus gets less hot, and there is less probability of its being pierced; secondly, the vacuum lasts longer, at least this was the case with my apparatus; and thirdly, the apparatus produces stronger X-rays. In apparatus which was either not sufficiently or too highly exhausted to allow the Ruhmkorff coil alone to work well, the use of a Tesla transformer was of great advantage.

The question now arises—and I may be permitted to mention it here, though I am at present not in a position to answer it—whether it be possible to generate X-rays by means of a continuous discharge at a constant discharge potential, or whether oscillations of the potential are invariably necessary for their production.

§ 20. In § 13 of my first communication it was stated that X-rays not only originate in glass, but also in aluminum. Continuing my researches in this direction, I have found no solid bodies incapable of generating X-rays under the influence of cathode rays. I know of no reason why liquids and gases should not behave in the same way.

Quantitative differences in the behavior of different bodies have, however, revealed themselves. If, for example, we let the cathode rays fall on a plate, one-half consisting of a 0.3 mm. sheet of platinum and the other half of a 1 mm. sheet of aluminum, a pin-hole photograph of this double plate will show that the sheet of platinum emits a far greater number of X-rays than does the aluminum sheet, this remark applying in either case to the side upon which the cathode rays impinge. From the reverse side of the platinum, however, practically no X-rays are emitted, but from the reverse side of the aluminum a relatively large number are radiated. It is easy to construct an explanation of this observation; still it is to be recommended that before so doing we should learn a little more about the characteristics of X-rays.

It must be mentioned, however, that this fact has a practical bearing. Judging by my experience up to now, platinum is the best for generating the most powerful X-rays. I used a few weeks ago, with excellent results, a discharge apparatus in which a concave mirror of aluminum acted as cathode and a sheet of platinum as anode, the platinum being at an angle of 45 deg. to the axis of the mirror and at the center of curvature.

§ 21. The X-rays in this apparatus start from the anode. I conclude from experiments with variously-shaped apparatus that as regards the intensity of the X-rays it is a matter of indifference whether or not the spot at which these rays are generated be the anode. With a special view to researches with alternate currents from a Tesla transformer, a discharge apparatus is being made in which both electrodes are concave aluminum mirrors, their axes being at right angles; at the common center of curvature there is a "cathode-ray catching" sheet of platinum. As to the utility of this apparatus I will report at a later date.

EDITORIAL

A New Kind of Rays

(Reprinted from the Editorial Page of the J. A. M. A., Feb. 15, 1896)

The general interest in the recent discovery of Prof. Röntgen, the details of which now fill the daily press and which were at first received with incredulity by the public as probably a scientific hoax, seems to call for some notice. . .

In regard to the scientific question as to whether the results obtained by experimenters are due to the previously recognized cathode rays or to a new form of radiation as Prof. Röntgen suggests we can, of course, express no opinion; it is a matter to be decided by physicists. The fact that we have, however, a force, for that is what it may be called, that will act on the sensitive chemicals of the photographic plate through flesh, cartilage, skin, and other tissues of the animal body, is enough to be fertile of practical suggestions to any thinking physician or surgeon. The further fact that these rays go directly through prisms and lenses without modification or change of course adds to their possibilities in a medical point of view; it insures the accuracy of the image from distortion by refractive power of the different solids and fluids of the body. The further fact that in a general way only the density of the medium penetrated seems to affect them is suggestive of practical medical and surgical possibilities; it hints at future valuable physiologic revelations as well as diagnostic aids. It is only a hint, however, and whether it is to be ever realized to any extent is perhaps open to serious question. As regards its therapeutic possibilities which have already become the plaything of the popular imagination, they may be left to future investigation; they are not in a stage as yet for medical opinions to pass on the question of even their existence. There will doubtless be an extensive advertisement of cathode ray baths, x-ray treatments, etc., but it is to be hoped that any active exploitations of these will, until the matter is more elucidated by accurate scientific researches, be confined to the irregulars who have no standing in the regular medical profession.

The real utility of the discovery has so far been demonstrated to a limited extent in the field of surgery. A few accounts have appeared in the lay press of needles, bullets, etc., having been detected lodged in the tissues, and some light has been thrown on pathologic diagnosis in one or two cases. In France, M. Lannelongue believes he has been able to show by this method that in a femur affected with osteomyelitis the destruction of bone progresses from the center to the periphery rather than in the opposite direction as had been previously held. When it is considered that the discovery is as yet only a few weeks old, and that students all over the civilized world are laboring to investigate it and to perfect the methods of its application, it may not be unreasonable to hope for much more important results in the near or remote future. At present, however, the limitations of the methods are too great and the medical nature of the discovery is, as yet, a largely unknown quantity. Its surgical utility in certain ways has probably been sufficiently indicated by what has been already done, but enthusiasm as to its future should be tempered by a scientific spirit of moderation that proves all things before building its faith upon them.

After Fifty Years

"It is only a hint. . . ." The skepticism with which Röntgen's epochal communication, "On A New Kind of Rays," was received finds expression in these words from the editorial reprinted on the opposite page, the first official recognition, by the *Journal of the American Medical Association*, of what has proved to be one of the most important scientific achievements of the past century. Today it seems inconceivable that, in spite of the meager reports then at hand, the benefits which were destined to accrue to humanity from this discovery were not more clearly envisioned.

Fortunately, there were those by whom the possibilities, however vague, were accepted as a challenge. Step by step, on the basis of scientific research, this intrepid group proceeded to improve the crude equipment at first available, to devise new technics, to unearth the hidden disease processes of the body, to venture into new fields of application. These developments are traced in greater detail in the following pages. But those men of vision, who accomplished so much with so little, paid a price for their achievements in suffering and even death—the late effects of the then inadequately known rays. It is to the memory of those early pioneers, as well as to Röntgen, that this issue of RADIOLOGY is dedicated.

Many fields were to feel the impact of Röntgen's discovery. In the science of physics radical changes were to stem from it. The development of spectrometry by Bragg not only made possible studies of the atomic structure of recognized crystals but showed that many organic substances, as silk and rubber, are basically crystalline. Industry profited by the radiographic examination of structural materials, and the rays which Röntgen had demonstrated in the peace of his laboratory became an asset in time of war for testing the integrity of castings and other strategic materials. Already radical changes in our mode of living have grown out of the application of electronic principles, and the future promises still more revolutionary developments.

In the field of medicine, roentgenology has advanced during the past fifty years from feeble beginnings to take its place among the most respected specialties. At first it was devoted largely to the detection of foreign bodies and changes in the osseous system, but as early as June 1896 one observer was able to reveal a concretion in the kidney. Other pioneers were soon demonstrating lesions elsewhere in the body, proving to a startled medical world that it had at its disposal not merely a scientific curiosity but an agent capable of making visually perceptive, in the living, many anatomic, physiologic, and pathologic processes which had hitherto been demonstrable only at autopsy, or at best on the operating table.

During the same early period biologic reactions, as an irritation of the eyes and a persistent dermatitis of the hands, led certain workers to speculate upon the therapeutic possibilities of the new discovery. It is true that the feeble emission of rays obtainable with the tubes then available had but a minimal effect, but as more efficient apparatus was developed and new knowledge of the properties of the rays was acquired, their therapeutic effectiveness became increasingly apparent and their binary character was established.

To Wilhelm Conrad Röntgen full credit must be given for the genius which led him to recognize a hitherto unknown form of radiation, but for its full development roentgenology has been dependent upon the sustained effort and collaboration of many scientists in many lands. It demonstrates again the truth that science is universal, without limitations of nationality or race.

Development of Diagnostic X-Ray Apparatus During the First Fifty Years

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INTERNAL MEDICINE, surgery, and the clinical specialties have availed themselves of the fruits of the physical and chemical age to such an extent that the modern internist would be handicapped severely if he were deprived of his thermometer, sphygmomanometer, electrocardiograph, and sulfonamides, while the surgeon would sorely miss local anesthetics and the myriad appointments of the present-day operating room, but our colleagues' dependence on physics, chemistry, and engineering is as nothing compared with ours. While it is true that we radiologists are useful in proportion to our excellence as physicians and that it is our clinical education and experience that count most, still we are powerless to bring those attributes into play until we have first made good-quality roentgenograms, produced a good fluoroscopic image, or generated a beam of therapeutic rays of precisely known quality, quantity, and dimension. As a result of our great dependence on apparatus and technic, it is only natural that these matters have occupied a large place in our attention and required the expenditure of a great deal of our time.

As late as the close of the nineteenth century, our ablest surgeons and the departments of surgery in our leading universities deemed it proper and, in fact, mandatory that they devote a considerable portion of their attention to the devising of new instruments and new operative procedures, but in recent years such pursuits have come to be considered unworthy. By false analogy, some critics have contended that radiologists should now leave all of their technical problems to the engineering staffs of the commercial manufacturers. It seems safe to assume that eventually our radiological tools will reach such a degree of perfection and standardization as to allow us to ignore the details of their construction and operation, devoting ourselves exclusively to the medical phases of our work, but that day is not yet here.

Our interest in technical matters has not remained static, however, but has shifted with the years, and as certain parts of our equipment have approached perfection we have been quite as willing as our surgical colleagues to drop consideration of those parts in order to conserve time and effort for clinical work. This shift in interest may have been scarcely discernible to those who were experiencing it, but as one looks back over the half century and for convenience breaks down the period into five decades, a fairly definite pattern becomes visible.

FIRST DECADE

By the close of the first decade (1905), almost every part of the body had been studied more or less successfully, but the principal clinical use of x-rays was for the care of fractures and dislocations and the detection of foreign bodies, and even in these fields the use was extremely limited. X-ray tubes were still primitive in design and fickle in performance, and intensifying screens were of a quality that deserved and received little consideration.

The small laboratory type induction coil operating on storage batteries and provided with a mechanical interrupter had given way, in this country at least, to the static machine which, in turn, was now in the process of being displaced by more powerful induction coils supplied from power lines and provided with electrolytic or mercury jet interrupters.

SECOND DECADE

The next ten years saw an enormous spread in clinical roentgenology, and by

the close of the second decade (1915) physicians generally employed x-rays, or at least wished that they might be able to employ them, in the examination of the chest and the alimentary tract, as well as for all of the injuries and diseases of the skeletal system. On the technical side, the so-called interrupterless transformer had about displaced induction coils, and the recently introduced Coolidge tube was shortly to bring complete obsolescence to that temperamental prima donna, the gas tube.

The importance of the technical changes of that second decade can scarcely be appreciated by one who did not work at radiology during that period. At their best, induction coils had been a terrible nuisance and it seemed at times as though gas tubes had been invented for the specific purpose of trying men's souls. The induction coil required direct current power in an amount not conveniently provided by storage batteries, and in those American communities where the only available power was alternating current this meant that one must provide either a large, expensive motor generator set or a temperamental and inefficient electrolytic rectifier.

The Electrolytic Rectifier: This consisted of a pair of metal-plate electrodes immersed in an alkaline electrolyte, such as ammonium phosphate, sodium bicarbonate, or sodium and potassium tartrate. The positive electrode was made of aluminum, the negative usually of steel, and plates and electrolyte were contained in a glass or porcelain jar partially immersed in the water of a cooling bath.

The aluminum plate was either "formed" by the manufacturer or was "formed" on the job by passing a low current through the cell for a few minutes. By "forming" was meant the deposition on the aluminum of a thin white coating of aluminum salt which polarized the electrode, allowing negative electricity to flow freely through the electrolyte from the indifferent electrode to the aluminum, but opposing a flow in the opposite direction. Four cells were employed, connected so that full-wave rectification was accomplished.

Under the best of operating conditions, electrolytic rectifiers were a poor expedient and the conditions were seldom good. Usually rectifiers were neglected, water that evaporated from electrolyte and cooling bath was not replenished, metal parts were allowed to corrode, and efficiency fell to a low level.

Early Forms of High-Voltage Rectifier: When the induction coil was well designed, the current supply unidirectional, and the interrupter of good design, the high-voltage current produced by the secondary of the coil was approximately unidirectional. Under practical operating conditions, however, the amount of inverse current might be considerable and, inasmuch as inverse current was deleterious to x-ray tubes, considerable effort was expended to suppress it. One of the devices used for this purpose was the so-called Lodge valve tube, which consisted of a pear-shaped vacuum tube provided with a cathode and an anode. The cathode was a large, coiled, aluminum rod that filled the body of the tube; the anode a small disk of steel or other metal located well back in a narrowed arm of the tube. As in all gas tubes, so in this one, the electrons that were essential to conduction were emitted from the cathode as a result of bombardment by positive particles. The anode, by virtue of its smallness and protected location, was bombarded by few positive particles during the phase that it was at negative potential and, because of its physical composition, emitted few electrons for each impact. The cathode, on the contrary, was richly bombarded by positive particles and, being aluminum, gave out copious electrons for each impact. When one or several Lodge tubes were connected in series with the x-ray tube, the useful current of the induction coil passed through the system without much attenuation, while the inverse current was largely suppressed. Similar gas valves were used by Hutton in his early attempts at the rectification of the output of A.C. transformers, but it was not until many years later that hot-cathode valves made such circuits practical.

The Electrolytic Interrupter: The Wehnelt interrupter, as used in this country, usually consisted of a platinum-rod positive electrode, a lead negative electrode, and an electrolyte of 20 per cent sulfuric acid. These electrodes were mounted in a glass or porcelain jar containing 20 per cent sulfuric acid, the jar, in turn, being partially immersed in a cooling water bath. Three such cells were commonly used, one having a large point, one a small point, and one a point of intermediate size. The platinum points protruded through the tips of porcelain candles, the amount of protrusion being controlled by a hand-operated screw, and a series of knife switches made it possible to employ any one or any combination of the points. Interruption was accomplished by the alternate formation and collapse of an insulating coating of gas bubbles about the exposed platinum tip.

Before making a plate, the operator tinkered with the rheostat and the interrupter points until the tube "backed up a five-inch spark" (*i.e.*, operated at 85,000 volts peak) and seemed to be drawing about the proper amount of current. He estimated current by the sound of the interrupter and the intensity and distribution of the apple-green fluorescence which was characteristic of gas tubes.

Exposing more platinum in the interrupter increased the current that could flow through it and decreased the rate of the interruptions, but there was no provision for measuring the rate of interruptions, and the ammeter that usually was connected in series with the primary of the induction coil gave little indication of the amount of x-ray that was being produced by the tube.

Since the one variable that could be controlled was development, it was the skill and diligence of the darkroom worker that determined the quality of the x-ray plates. Not much attention was paid to the strength or temperature of the solutions. The plates were developed one by one in trays under constant visual control and were transferred to the hypo at the exact moment when the technician's practised eye detected, by means of the red light, that the image had "struck through to the back of the plate."

Mercury Interrupters: Motor-driven mercury interrupters were fairly satisfactory if a condenser was connected across the break, and particularly when the dielectric was gas. It was more common, however, to use kerosene and, after being used for a few hours, mercury and kerosene became blended into a sort of mercury ointment.

It was during this second decade that I spent a morning watching one of our ablest American radiologists conducting gastro-intestinal examinations. The list was enormous—ten patients in one morning—and I marveled at the fact that he had almost completed the last examination before the mercury interrupter, which was mounted on a shelf on the wall, broke down and had to be overhauled by the engineer. I have great admiration and respect for that radiologist, but when he told me that there were some mornings when he did as many as twelve examinations without a breakdown of the interrupter, though I did not openly question his veracity, still I mentally concluded that enthusiasm for his calling had somewhat clouded his respect for the absolute truth.

Mechanical Rectifier: Those fortunate few whose hospitals and offices were provided with direct current power were spared the inequities of the electrolytic rectifier, but all users of induction coils were faced with the challenge of the interrupter, and everyone recognized that the challenge was not adequately met. It was small wonder, therefore, that when Snook introduced the combination of the closed-core A.C. transformer with a motor-driven centrifugal switch or rectifier, radiologists, instead of calling it by the straightforward name "mechanical rectifier," hailed the machine as the interrupterless transformer. It did away with that abomination, the interrupter, and in their eyes that was what counted most. With this change, the tables were reversed in the matter of A.C. *versus* D.C. power supply. Now the

radiologist who had A.C. power was the fortunate fellow because his mechanical rectifier could be driven by a small, practically trouble-free, synchronous motor, the transformer drawing its power directly from the line, whereas in D.C. installations a rather heavy, somewhat expensive, synchronous converter or so-called rotary converter drove the rectifying switch and also supplied alternating current for the x-ray transformer. The commutator and brushes of the converter required far more attention than the simple slip rings of the synchronous motor, but much more important was the disadvantage that for a converter of reasonable size and cost the power that could be supplied to the transformer was relatively small. Later, as self-rectification brought in small portable and bedside units, the user of D.C. power was put to the cost and inconvenience of providing for each of them a small but none the less heavy and rather expensive synchronous converter to change D.C. to A.C. This advantage of A.C. over D.C. has continued throughout the decades that have followed.

THIRD DECADE

The third decade, which closed in 1925, was unusually fruitful, both clinically and technically. In this period chest films came to be considered indispensable in the handling of pulmonary disease, pyelograms began to occupy a similar position of importance in urology, and at least in the larger centers it became all but unethical to attempt to manage diseases of the gastro-intestinal tract without the aid of x-rays. Cholecystography was introduced, and cardiologists began to be interested in the application of x-rays to their work although, of course, they had been used to some extent in cardiology from the very earliest years, particularly among the French.

Early in the decade the radiator-type Coolidge tube had sponsored self-rectification for small portable bedside and fluoroscopic units.

Double-disk mechanical rectification made it possible to bring the milliammeter down out of the high-tension system and mount it on the control board, closed-core transformers and autotransformer controls were in general use, and time-switches were greatly improved. Double-coated films and double-intensifying screens proved to be an enormous improvement over plates and single screens and, most important of all, Potter's recently invented moving grid opened the way at last to adequate raying of the skull, trunk, and pelvis.

Potter Grid: The importance of Potter's work was recognized and warmly acclaimed by contemporary American radiologists, but the excessive modesty and self-abnegation of Potter's original papers have tended to blind the younger generation to the enormous debt they owe to him. Before Potter, good films of the skull, hip, and other thick parts could be obtained only by the expedient of narrowing the incident beam to small diameter. Full-sized films of the skull, abdomen, and pelvis we owe directly to him.

Bucky, it is true, had laid the ground work by learning from the physicists their concept of the scattering of x-rays and teaching that concept to radiologists. Prior to this we had understood fairly well the phenomena of absorption, transmission, and characteristic emission, but most of us owe to Bucky our appreciation of the fact that some of the radiation impressed upon the surface of the patient's body is scattered out of its straight-line course with resulting blurring of the x-ray image. Scattering is greatest when the voltage is high, the mass of tissue large, and the incident beam broad, so it can be reduced in amount by lowering the voltage, coning the beam, and compressing the part. Bucky taught us that most of the scattered radiation that was formed could be prevented from reaching the film by interposing between patient and film a honeycomb-like metal member that he termed a diaphragm. The interstices of Bucky's diaphragm were, in fact, little metal tubes oriented so that their bores were parallel with the radii of

the spherical angle formed by the incident radiation. Unscattered incident radiation passing through the patient's body passed on through Bucky's diaphragm to reach the film, but the scattered radiation, since it deviated from the radii of the sphere, suffered absorption in the walls of the metal tubes. Bucky's theory was sound as far as it went, but it did not go far enough and the films that he made were practically useless because of the overlying pattern of the diaphragm. By that partially developed theory, since the radiation had a spherical distribution, the suppressor had to be in the form of a segment of a sphere and, therefore, no motion that could be devised for it would wipe out its image. Here Bucky stopped and here the matter stood until Potter attacked the problem in 1913.

I don't know whether Potter theorized, "Since we can't deal with a sphere of radiation, suppose we see what happens if we assume a cylindrical rather than a spherical distribution." Perhaps he just experimented and built his theory as he went along but, in any event, by 1917 he had the answer and, since grids became commercially available in the early twenties, that answer has been at work in x-ray laboratories all over the world. Potter's answer was something like this: "The suppressor doesn't have to be a system of tubes arranged as a segment of a sphere. It works almost exactly as well if it is a series of strips arranged as a segment of a cylinder and, unlike Bucky's spherical diaphragm made up of tubes, a cylindrical grid, composed of strips, casts on the film no image of itself provided it is in uniform motion while the exposure is being made."

I have said that contemporary American radiologists appreciated the importance of Potter's work, but the Europeans of that day appreciated it, too. When I visited German and Austrian universities in the spring of 1923, the most common question that was put to me by their radiologists was: "How may we obtain one of Potter's grids?"

There have been developments with the years, of course. The grid, originally curved, has been made flat; for certain applications it need not move at all and, when it does move, the modern trend is to drive it continuously by means of a reciprocator instead of starting it and stopping it for each exposure, but these are mere variations on Potter's original theme. Let us give credit to Bucky for posing the problem, but particularly to Potter, the fellow who solved it after it had been posed.

FOURTH DECADE

By 1935, which marked the close of the fourth decade, radiology was generally recognized as a legitimate and independent member of the group of medical specialties, with its own body of technical and clinical knowledge, its own facilities for advancing and transmitting that knowledge, its own journals, societies, and examining boards. Most of the tissues of the body and most of the diseases to which those tissues are heir were now regularly subjected to x-ray examination. In particular, this decade had seen the inclusion of the central nervous system, the vascular system, and the genital system among those parts of the body for which x-ray examination had become an almost invariable part of the routine. Technical advances had continued throughout this decade also.

Valve-Tube Rectification: Rectification by means of hot-cathode valve tubes had almost completely displaced mechanical rectification. At first valve tubes were expensive and erratic, and the attempt to economize by using only a single valve brought nothing but trouble and was soon abandoned. However, with the development of small, oil-immersed, four-valve sets, it seemed that at last stability may have been reached in the development of the high-voltage generator.

Shock-Proof Tubes: The shock-proofing of tubes passed from an experimental to a thoroughly practical stage; the rotating anode tube, long known in principle, had reached a degree of ruggedness and was beginning to approach a price which would

allow its wider employment, and the filming fluoroscope began to appear in the catalogues of most of the manufacturers. Planigraphy and the thrice-resuscitated x-ray kymography were creating something of a flurry but were destined to be retired to a place of minor importance, and condenser discharge machines and three-phase generators, after a brief and limited popularity, had entered a decline.

FIFTH DECADE

It is, of course, too soon to evaluate the lasting work of the fifth decade, whose close we are now celebrating, but on the technical side two accomplishments at least seem likely to survive. The first is the perfection of *microfilming* and its adaptation to mass radiography of the chest. As in so many other phases of x-ray work, the concept of microfilming is almost as old as x-rays themselves but the harnessing of the idea and the breaking of it to practical, effective, wide-scale use have come only in very recent years. At the moment the method is practical only for examination of the chest, and serious technical obstacles will have to be overcome before it can be extended to all parts of the body, but there is little reason to doubt that these obstacles will be surmounted within the decade we are about to enter.

Photoelectric Timers: Another accomplishment of the fifth decade is photoelectric timing. As this article is being written, timers for microfilming are in commercial production and presumably will be in wide-scale use during the demobilization of our Armed Forces. Photoelectric timers for general radiography are still in the experimental stage, but there is every reason to believe that they, too, will become commercially available within a very few years.

CLINICAL ASPECTS

On the clinical side there is not the slightest justification for feeling that we may rest upon our laurels. It is true that every system, almost every tissue, and a vast number of the diseases have now been and are being studied by x-ray, and that a great deal of information about them has been collected, but there is scarcely a phase of this work that could not be done better than we now do it. It will be many years, indeed, before students considering radiology as a life's work will be justified in turning from it to something else for the reason that all the discoveries have been made and nothing remains to be done. Actually, the amount of work remaining to be done is prodigious and, in addition to improvement and extension of the body of radiological knowledge, we are faced with the pressing job of making available to the population at large that amount of radiological skill that has already been developed.

SOCIAL ASPECTS

Even in the cities good-quality radiology is available to only a fraction of the population, and outside of the cities the situation is appalling. It will require the expenditure of much thought and energy to rectify the situation and at the same time not interfere with the orderly development of our specialty. Certainly there are two extremes that should be avoided. On the one hand, radiology should not be pauperized to the point where able young physicians no longer care to enter it and, on the other hand, we must oppose all efforts within our ranks to perpetuate the economy of scarcity which in the past made it possible for an inadequate number of radiologists to earn large incomes by caring for a comparatively few patients. There may be a few unscrupulous lay administrators who see only good in the reduction of the radiologist to the role of a subservient, underpaid employee, but the majority of clinic and hospital administrators hold no such views. On the other hand, though there may be a few unenlightened radiologists who favor trade-union tactics for the retaining and improving of advantages now possessed by us, most of our colleagues have no sympathy with such views. But though we ignore extremists on both sides and assume that the majority of radiologists and administrators have the same ends in view,

it does not follow that their task will be easy or immediately successful. The guiding principles are clear, however, and if we will keep them constantly in view, the details can be worked out.

Methods of economizing on time and material must be sought and, when found, adopted. Expensive, time-consuming routines which have only the merit of usage but serve no useful purpose must be abandoned, and, wherever possible, the patient-doctor ratio must be increased. Of course, such practices can be abused with the result that the radiologist is overworked or is made to do shoddy work, but abuses benefit no one and must be avoided.

In the decade that lies ahead, we radiologists should be out in the lead of our profession, exploring the path that medicine should follow in adapting itself to the changed economy that is bound to affect every phase of our national life, since some of the problems are not as new to us as they are to our colleagues in other branches of medical practice.

Undoubtedly much radiology will be supplied at federal expense to the millions of new war veterans. It should be our aim to assist that work in every way and by counsel and example to mold public and official opinion to the idea that the government will have to employ first-quality radiologists if first-quality work is to be expected. Industry, municipalities, and similar agencies presumably will increase the amount of radiology made available to groups for whom they are responsible, and our co-operation here should be the same as in the case of the veterans. And what of private practice? I, for one, have no fear that a people who have just victoriously concluded a war for the preservation of the American way of life will now wish to destroy that way.

Those attributes of private practice which suffer by comparison with the quality of radiology that will be practised in the Veterans Administration and in various types of partially or wholly subsidized clinics will and should fail and disappear. On the other hand, a vigorous, excellent, though perhaps somewhat smaller program of private American radiology will be welcomed not only by that fraction of the population that can afford its somewhat higher fees and more personalized service but also by the nation as a whole, as a standard-setting agency for government hospitals and reduced-rate clinics. In the long run, the public does a surprisingly good job in evaluating the quality as well as the cost of the medical care it receives. It will not indefinitely pay higher fees for the subtle advantages of being cared for in a private office unless the medical quality of the care received is at least as good as that available in low-cost clinics and, on the other hand, will not be content to reap the financial advantage of the clinic unless it is convinced that the quality of its work is good.

PROBLEMS FOR THE FUTURE

Even if I were inclined to fancy myself a prophet, still I would abstain from radiologic prophecy lest I survive for a few more years to experience the embarrassment of the eminent Philadelphia physician who, shortly after the discovery of x-rays, predicted that x-ray apparatus was so expensive and its employment so time-consuming that it could never come into general clinical use, or that of my Chicago colleague who, a number of years ago, concluded that x-ray apparatus had reached a final state of perfection except possibly for some simplification of design. But it is not an act of prophecy to point out radiological chores that need doing and to express the hope that in the years ahead someone may attend to them.

Better Films: Silver halide suspended in water-soluble gelatin always has been and perhaps always must be the only really feasible photographic medium, but our work would benefit if it ever became possible to incorporate the active photographic agent in the base itself, with the complete abandonment of a surface emulsion and the substitution of gases or chemicals dissolved in volatile solvents for the aqueous processing solutions that are now employed. Such

films—possibly quite incapable of attainment—might be expected to be vastly more durable than those in use today and their processing might be much more rapid.

Better Screens: The screen situation is ripe for change, and with the widened chemical interest in fluorescent materials for lamps, paints, television tubes, etc., change may well be expected. Already speed and definition have reached a respectable degree of excellence, but cost and lack of durability are still excessive. No one expects a white shirt to last more than one summer day without a trip to the laundry, and the garter manufacturers urge that their product be looked upon as expendable and rather short-lived, but we have been educated to believe that it is logical for expensive, fragile, white intensifying screens to make thousands of trips to the loading bench before they have paid their way and can be discarded. Present-day screens may be washed, it is true, but not very often and not very successfully and, even when every feasible precaution is taken, deterioration is rapid. Those of us who periodically scoop the treasury to install new screens in all our cassettes know only too well the difference between the excellent quality of films that can be produced when screens are new and the shabby appearance of those made only a few weeks later when deterioration has begun.

Two obvious remedies are at hand—one still entirely neglected, the other now being worked at. The first is a "clean towel service" for screens. It should be possible to contract for screens by the year, the representative of the manufacturer to replace screens as soon as defects develop, perhaps with some additional insurance premium to cover those damaged by accident or carelessness rather than by normal wear and tear. This suggestion is based on the knowledge that the materials used in the making of a screen cost a microscopic fraction of its selling price and the assumption that that price largely represents, therefore, the labor and overhead of manufacture and distribution. Many more screens would be required under my plan, and somewhat more labor would have to be expended, but the real cost of such a service might be surprisingly little more than that of the present system, which is so extremely unsatisfactory. The other remedy is the provision of a tough abrasion-resisting surface coating that really will stand washing, and that matter, I am glad to say, is now receiving the attention of screen manufacturers.

Better Cassettes: Cassettes have become better in recent years, but they still need improvement. In anticipation of phototiming, the backs should be made of standard-thickness aluminum without lead and with at least the central area free of springs or rivets. Frames should be made of steel of a quality that combines, as far as possible, maximum lightness and toughness with maximum resistance to rust. Better means should be sought for the mounting of screens, and the front of the cassette should be provided with a flush marker which will photograph onto the film the serial number of the cassette and the name or initials of the hospital, clinic, or individual radiologist. The serial number should appear, also, on the back of the cassette, so that when films show defects that are caused by faults in screens or cassettes the faulty cassette may easily be located and removed from service.

Better Tubes: Our gratitude for the excellence of the x-ray tubes available in this, the fiftieth year following the discovery of x-rays, should not blind us to the need of still further improvement. Having myself experimented since the early twenties with the forced circulation of the insulating oil used with diagnostic x-ray tubes, I am convinced that oil circulation and forced cooling of the oil are important. They are employed now by one manufacturer, but the practice should become general and, if there are valid patents restricting such general use, some program should be worked out for the granting of licenses under those patents.

With the years, rotating anode tubes have become smaller, longer-lived, quieter, and somewhat less expensive, though

there is ample room for improvement along all these lines; but their cooling remains a serious problem, particularly when one wishes to employ them in the filming fluoroscope. Long ago Coolidge patented and then abandoned a tube in which not merely the anode but the entire tube rotated, a magnetic field operating through the glass to deflect the cathode stream so that the focal point was held fixed in space while the spinning mushroom-shaped target rotated beneath it. Modern, short, cylindrical tubes are much better adapted to such a system than were the long, globular tubes of thirty years ago, and in the intervening years much has been learned about the focusing of electrons by combinations of electric and magnetic fields. The bearings of such a rotating tube would be oil-immersed ball bearings of standard design and, therefore, extremely quiet and practically imperishable, and the rotation of the tube within the oil housing could be made to provide vigorous circulation of the oil. If a good blower were added, a tube of this sort should excel all others in its ability to eliminate the heat generated in the target and thus be superior to others for all phases of diagnostic x-ray work, and particularly for use in the filming fluoroscope.

Dr. Coolidge's company would be the logical people to undertake a modern development of his old idea, but if they are not interested, others perhaps may be induced to take up the matter, for the patent has long since expired and the field is open to anyone.

Film Processing: Our record of achievement in the processing of x-ray film is nothing to brag about. Beginning with Robert Kelley's little motor-driven teeter-totter for rocking trays, we have improved a little on the darkroom methods we inherited from the daguerreotypers, but not much. Our constant temperature devices seldom are accurate; facilities for preparing, handling, and changing solutions are primitive; wash tanks and driers, though better than they were ten years ago, still are far from satisfactory. While we have been putting up with our archaic methods, moving picture processors, military Air Force photographers, and industrial x-ray engineers have made great strides in automatic processing and, now that the war has ended, some of the manufacturers who have been thus employed are seriously at work adapting their product to the quite different conditions of clinical radiology. It is high time that they have begun to do so because with the growth of phototiming, the automatic development of clinical x-ray films becomes increasingly important.

The ideal installation of the future will be a stainless steel unit that receives exposed film at one end and delivers dried film at the other, with a minimum lapse of time and with provision for the temporary removal of emergency films as soon as fixation is completed. Processing solutions will be continuously replenished, either by gravity or by means of pumps, and these solutions will be conducted through large stainless steel tubes having a minimum of pipe fittings. The solution lines will pass through strainers of ample size and of a design that allows easy, rapid, daily cleaning, and there will be precise and rugged machinery for maintaining temperature at the desired point. Finally, such an ideal installation will include a simple but well constructed phototube densitometer for the daily reading of test strips. Even now automatic developing is employed in a few x-ray laboratories, but the practice should become general and the apparatus required for it should be standardized rather than custom-built for each installation.

Film Handling: When the x-ray team consists of one physician and a single helper who loads the cassettes, operates the machine, processes the films, prepares them for reporting, and then transcribes the dictation, little is needed in the way of formal office procedure, but in clinics which employ dozens of workers and conduct hundreds of examinations each day there is confusion, delay, and costly waste of effort unless an orderly routine is set up and adhered to. There is a field here for recent graduates from university schools of business or for ex-soldiers with experience in

office management, and an opportunity, too, for the makers of office appliances.

Film Identification: In a large service it is not feasible to mark films by the simple procedure of introducing typewritten labels between film and screen as the cassettes are loaded. Instead, most laboratories use lead letters or numbers that the technician places on the table top or sometimes directly on the cassette. This method is better than nothing but has shortcomings so well known to radiologists that they need not be enumerated here. Photographing name, date, and number on the film after it has been taken to the darkroom and removed from the cassette requires that the darkroom technician be able to identify the top and the "butter side" of the film and has other practical disadvantages. I believe that there would be a market for a printer that employed x-rays rather than light and was located not in the darkroom but out in the exposing room near the film pass-box. To use such a printer, cassettes would have to be equipped with a small rectangular lead plate cemented to the bakelite front so that a corresponding segment of the film would be protected from radiation at the time the exposure was made, and for each patient there would have to be provided a small lead stencil bearing his name and number. The printer would contain a built-in stencil showing the name of the institution and a date stencil that could be changed daily. When all of the films of a particular patient had been made, the technician would insert the patient's name stencil into the printer and then, one by one, place the cassettes face up on the bed of the machine, with the segment of unexposed film registered directly above the stencil. A small, self-rectified unit located inside the printer would supply the beam of x-rays, the exposure being instituted by a foot-switch and terminated by a phototube. The radiation would pass upward through the back of the cassette and thus onto the film.

The resulting label would be uniformly legible, regardless of the density of the rest of the film, thus eliminating the necessity of punching dates and numbers onto the finished film and, though the initial cost of such a system would be considerable, it would be recovered shortly in a large service through savings in labor in the film room.

Stereoscopic Fluoroscopes: Stereofluoroscopes have come and gone with the seasons, but the final word on them remains to be said. Now that small, light-weight but rather powerful synchronous motors have become available, it should be a simple matter to construct a synchronous shutter that could be worn on a head band, and the provision of two tubes for the fluoroscope presents no difficulties. For non-stereoscopic fluoroscopy, the filament of one of the tubes would be turned off, but when stereoscopic vision was desired, both filaments would be lighted and x-rays would be produced alternately by the two tubes in phase with the alternations of the primary current. It would probably be necessary to provide a mechanical or electrical phasing device for the shutter.

Stereoscopic Filming: Two aspects of stereoscopic filming have long cried for attention—one needing merely the attention of good engineers, the other requiring the effort of an ingenious inventor. The engineering problem is the construction of a horizontal table for the rapid stereoscopic filming of such parts as the bowel, the kidney, and the gallbladder. The Potter grid would have to be of the reciprocating or the automatic reset type, and provision would have to be made for moving the first film out of the field and the second one in and for shifting the tube between exposures, but all of these are straightforward engineering problems.

The problem for the inventor is the old one of trying to obtain a pair of stereoscopic images of an infant's chest on a single film, the two exposures being made practically simultaneously. There is reason to believe that this is not incapable of accomplishment even with full-sized film, and when x-ray movies reach the stage of clinical feasibility, it probably will

be possible to make alternate exposures with an off-set x-ray tube so that each succeeding pair of images will be stereoscopic mates.

Cooling and Ventilating Darkrooms and Fluoroscopic Rooms: At the present time each radiologist must adapt to his own particular needs apparatus not specifically designed to meet them. Some profitable business awaits those manufacturers who are able to look beyond the sellers' market of the first few post-war years and are willing to expend thought and money for the design of cooling and ventilating units specifically suited to departments of roentgenology.

Microfilming: Now that apparatus for the microfilming of the chest has attained a reasonable degree of perfection, investigators and manufacturers must turn to the tougher problem of the microfilming of the heavier parts of the body. This will require lenses with greater speed and definition, obtained perhaps by radical alteration in design, fluorescent screens that are faster and of finer grain than those now in use, films that are faster and of better resolving power, and possibly special developer. If amplification of the fluoroscopic image yields to the effort that is sure to be expended upon it by investigators of the coming decade, that accomplishment may usher in universal microfilming over night. But improved microfilming need not wait upon that important innovation —it can be accomplished simply by the humbler process of improving the factors enumerated above.

Standardization: In closing, I wish to compliment x-ray manufacturers on the steps that have already been taken toward the standardization of certain parts of our equipment and to urge that they go as far as possible in this direction. They stand to gain almost as much as we by the introduction of high-tension cables with identical jacks at either end which can be used for either the anode or the cathode side and may be plugged into the transformer receptacles or the tube receptacles of every American manufacturer.

The number of different types of valve tubes should be reduced to an absolute minimum, and the over-all dimensions and the cathode and anode connections of valve tubes should be uniform, so that the tubes of any manufacturer may be used in the transformers of any other manufacturer. Obviously, the transition from chaos to order will be temporarily expensive and troublesome to manufacturer and user alike, and presumably during the transition period adaptors will have to be provided to allow the use of the new standard cables with tubes and transformers that antedate the era of standardization. Such difficulties will not be too great a price to pay, however, for the advantages that will accrue.

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Roentgen-Ray Tubes

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SINCE ITS birth, the roentgen-ray tube has undergone many radical changes. The general method of producing roentgen rays is, however, still the same, namely by accelerating electrons to a high velocity and then suddenly stopping them by collision with a solid body, the so-called target.

Depending upon the method used in generating the electrons, roentgen tubes may be classified into two general groups,

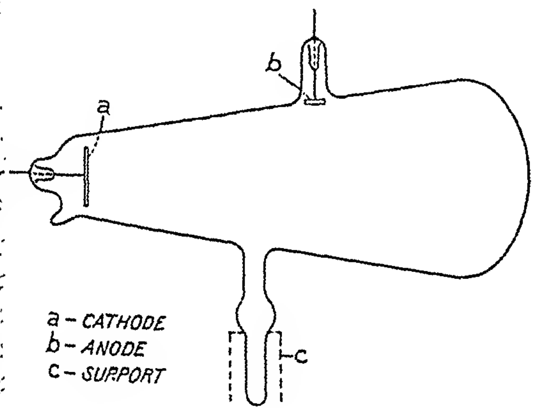


Fig. 1. Earliest type of roentgen tube.

gas tubes and high-vacuum tubes. In the first group, the electrons are freed from a cold cathode by positive ion bombardment, thus necessitating a certain gas pressure. In the second group, the vacuum is made as good as possible and the electrons are freed from the cathode either by heat, by bombardment from other electrons, or by the use of a potential gradient high enough to remove them electrostatically.

THE GAS TUBE

A. As First Used by Röntgen: The first roentgen tube (Fig. 1) was of a form previously employed by Crookes in his experiments on electrical discharges through rarefied gas. The electrons liberated by positive ion bombardment from the flat aluminum cathode were emitted in a direction perpendicular to its surface and, under the impressed voltage gradient, traveled in straight lines to the glass wall of the tube, where they generated roentgen rays.

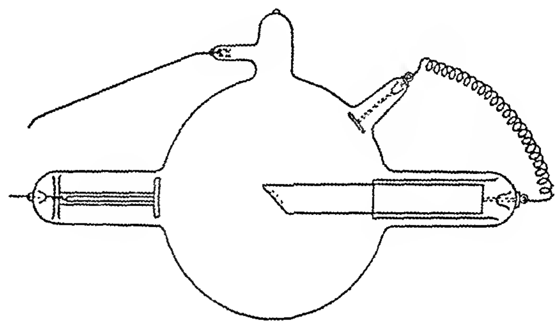


Fig. 2. Gas tube.

B. Early Modifications: This first roentgen-ray source was soon greatly improved by Campbell-Swinton through the introduction of a platinum foil target and by Professor H. Jackson through the substitution of a concave cathode for the original flat one. A later step of great importance was the addition of a device for regulating the vacuum. The early tubes were small and easily ruined, as so little energy was necessary to melt the thin electrodes and to overheat portions of the glass envelope.

C. Later Improvements: The power of the tubes was greatly increased by making them larger and with more massive cathodes and targets (Fig. 2). The development of the target in particular received much attention, resulting in a change from the use of a simple piece of sheet platinum to a platinum-faced disk of nickel brazed to a massive block of copper. This greatly increased the rate of heat flow away from the focal spot and, at the same time, increased the heat storage capacity.

A further substantial increase in tube power was later obtained by the develop-

ment of a tungsten-faced copper target, consisting of a disk of wrought tungsten onto which a large mass of oxygen-free copper had been cast in a vacuum. The principal properties desired in the target facing are high atomic number for maximum roentgen-ray efficiency, a high melting point, high thermal conductivity to allow maximum energies for a given size of focal spot, and a low vapor pressure to reduce the amount of target metal vaporized. Of all the chemical elements, tungsten combines these properties to the highest degree.

D. Limitations: The electrical characteristics of the gas tube were mainly determined by the gas pressure existing when the tube was carrying current. Owing to two opposing effects, this pressure could be either higher or lower than it was before the tube was energized. Heat development due to positive ion and electron bombardment tended to liberate adsorbed gas from the glass and from the electrodes and so to raise the gas pressure. On the other hand, there was an electrical pumping action during operation, tending to reduce the pressure.

Even though the pressure might remain constant, the electrical discharge through the gas tube was of a run-away character. To combat this and stabilize the discharge, it was necessary that the high-voltage source should have very poor regulation, that is, that its voltage should decrease rapidly as the current drawn by the tube increased.

If the pressure in the tube were too high, the voltage at all settings of the control would be too low. In the ordinary gas tube the only recourse then was to electrical clean-up. By operating the tube with current low enough to avoid appreciable heating, the gas pressure would gradually decrease.

If the pressure were too low, it could be increased by admitting gas from the regulator.[1]

[1] This assumed various forms, often consisting of a side-tube containing a chemical which upon being heated, as by the passage of a spark, would give off gas.

The initial pressure required for satisfactory operation was strongly dependent on the past history of the tube. The useful life was limited by the permanent electrical clean-up of gas and especially by the removal of adsorbed gas from the cathode. This last effect manifested itself by marked instability, finally becoming so bad that it was useless to add gas from the regulator as, on the application of high voltage, it would be immediately cleaned up. The tube could then be returned to its original condition only by rebuilding it with a fresh aluminum cathode, and it was necessary that this aluminum should contain hydrogen. It was apparently the gradual loss of hydrogen from the cathode that was most responsible for instability. This was, at least in effect, recognized by the manufacturers of such tubes, who carefully refrained from operating them any longer than necessary while connected to the pump.

As a result of the tube and circuit characteristics, it was difficult to know in advance what the voltage across the tube terminals during an exposure would be, and even difficult to know afterward what the roentgen-ray-producing voltage had been. The tube voltage was measured by means of a spark gap connected in parallel with the tube, but, as customarily used, this indicated the starting or break-down voltage, which was often much higher than the running voltage.

The size of focal spot was not constant but depended on the gas pressure and could vary appreciably even during an exposure. Not only this, but, as the pressure changed, the location of the focal spot could change also.

E. The Hot-Cathode Gas Tube: In the early hot-cathode tube of J. E. Lilienfeld (1), the main electrodes were the same as in the ordinary gas tube. By means of current flow between a pair of auxiliary electrodes, the cathode of which was heated, the gas of the tube was ionized, and, by varying the discharge current passing between the auxiliary electrodes, the conductivity between the main electrodes

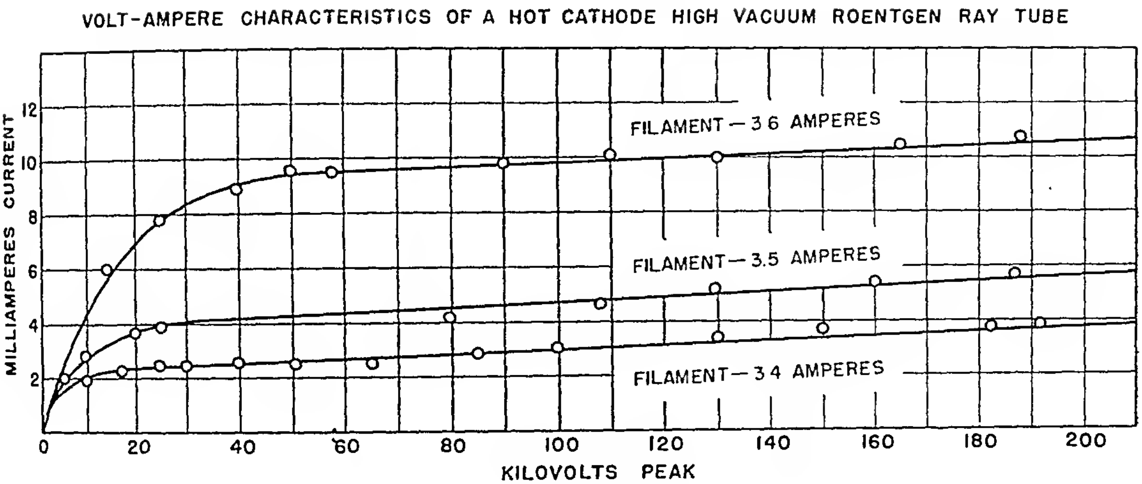


Fig. 3. Curves showing the relation of current to voltage in the hot-cathode high-vacuum tube.

could be controlled. The tube operated with a gas pressure somewhat lower than that of the ordinary gas tube. It was still a gas tube, however, and was not operable if the pressure became too low.

THE HIGH-VACUUM TUBE

Most of the troubles experienced with gas roentgen tubes could be associated with the gas itself and the positive ion bombardment that took place when that gas was present. It was very desirable to get rid of the gas, but this made it imperative to have some other mechanism for getting electrons out of the cathode.

Edison in his work on the incandescent lamp had shown that, in the vacuum of the lamp, current could be made to flow from the hot filament to an anode. Much additional light had been shed on this phenomenon by the work of O. W. Richardson (2) and others, connecting electron emission with the temperature of the hot body. The general belief had come to be, however, that the whole hot-cathode effect was due to gas contained in the cathode itself and that no current would flow from a hot cathode which had been completely freed from gas. Irving Langmuir's studies (3) of electron emission from hot tungsten lamp filaments demonstrated, however, that electron emission not only persisted in high vacuum but was favored by getting rid of the last traces of gas in the filament and other parts of the tube. In this way he was able to realize conditions which were stable and reproducible.

A. The Hot-Cathode High-Vacuum Tube: Coolidge (4), encouraged by the work of Langmuir, made a roentgen-ray tube with a hot tungsten filamentary cathode and a solid tungsten target and found that, even with the relatively high voltages and large masses of metal involved, it was possible to get and to maintain a vacuum sufficiently high to permit of stable and reproducible operation.[2] The relation of the current to the impressed voltage in a tube of this type is shown in Figure 3. The different curves are for different filament temperatures and show that, over the operating range of roentgen-ray voltages, the discharge current is practically independent of voltage.

In one of the first Coolidge tubes (Fig. 4) the cathode consisted of a spiral tungsten filament mounted behind a centrally perforated tungsten or molybdenum focusing disk, both filament and disk being set in the cathode side-arm, and the anode consisted of a circular tungsten disk attached to the end of a tungsten support rod. From the earliest form the design soon changed to that of Figure 5, with its

[2] The idea of using a hot cathode in a roentgen-ray tube was not new at this time, but the principle had never been successfully applied in a vacuum so good that positive ions did not play either an essential or harmful role. The hot cathode of A. Wehnelt and W. Trenkle (5) employed a lime-coated hot cathode as a main electrode but was not operable at useful roentgen-ray voltages.

different cathode construction and its more massive target.

B. The High-Vacuum Tube with Auxiliary Hot Cathode: J. E. Lilienfeld (6) later developed a type of hot-cathode tube in which the primary electrons were produced from a hot filament in a side-tube, the so-called ignition chamber. These primary electrons were caused to bombard the inside of the perforated main cathode, where they liberated secondary electrons. The electrons passing through the perforated cathode were accelerated, by the high electrostatic field, toward the target, with the production of roentgen rays. The tube was more complicated than the simple hot-cathode type and apparently possessed no advantages over the latter.

C. The Field-Current Tube: In the gas tube the emission of electrons from the cathode was produced by positive ion bombardment, and in the hot-cathode tube by thermionic effect. Experimental phenomena involving the pulling out of electrons from cold metals by high potential gradients have been observed and studied by many investigators.[3]

H. A. Rowland, N. R. Carmichael, and L. J. Briggs (8) made early experimental tubes in which the cathode and anode consisted of aluminum wires mounted with their co-operating ends only a millimeter apart. With the best vacuum which they could produce, these workers found that current would pass through such a tube between the ends of the electrodes, generating roentgen rays at a minute point on the end of the electrode which functioned as anode.

R. W. Wood (9) found that he could pass discharges from an induction coil between platinum spheres 1.5 mm. in diameter placed 1 to 5 mm. apart in a highly evacuated chamber over mercury, and that very penetrating roentgen rays were produced at the anode sphere. The experiments of both Rowland and Wood were clearly examples of field-current discharges.

Lilienfeld (10) developed a roentgen tube of this type in which the cathode was a wire with a pointed tip, placed a few millimeters from the target and facing a depression in the latter which served as the focal area. The function of this depressed area was to localize the focal spot which otherwise wandered about.

C. M. Slack and L. F. Ehrke (11) have developed a field-current tube for very rapid roentgenology, as for example, to depict a bullet in flight in its passage through an obstacle.

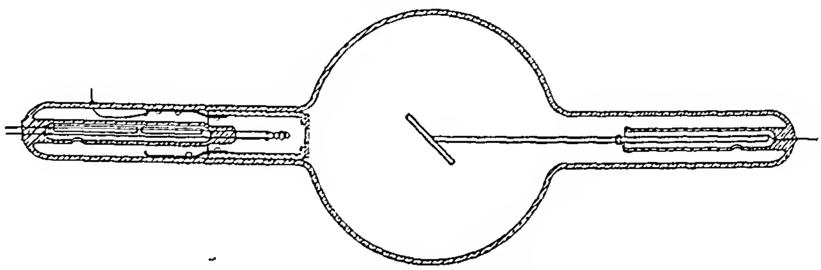


Fig. 4. Earliest type of hot-cathode high-vacuum tube.

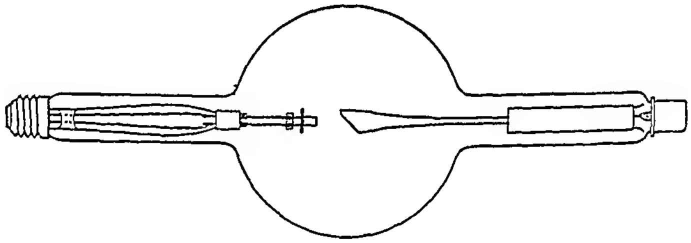


Fig. 5. First commercial model of hot-cathode high-vacuum tube.

[3] K. T. Compton and I. Langmuir (7) have reviewed the results of this work on field currents.

The electrical characteristics of the field-current tube resemble those of the gas tube in that the current and voltage are not independent of each other. Like the latter, it therefore does not have the flexibility of the hot-cathode tube, nor does it have the stability.

THE HOT-CATHODE HIGH-VACUUM TUBE

A. General Considerations

(1) *Inherent Advantages:* The main advantages of the hot-cathode high-vacuum tube over the gas tube are:

(a) *Flexibility:* Voltage and current may be independently varied at will.

(b) *Voltage:* The tube can be designed for much higher voltage.

(c) *Electrical Stability:* This permits more accurate reproducibility of results.

(d) *Non-Varying Size and Position of Focal Spot.*

(e) *Size of Tube:* For a given energy input the tube can be made much smaller, thus facilitating roentgen-ray protection and giving increased latitude in the design of auxiliary equipment.

(f) *Design of Tube:* Greater flexibility is permitted in the use of hollow anode construction to facilitate adequate roentgen-ray protection, to reduce scattered and stray radiation, and to generate roentgen rays at any desired location in the vacuum envelope.

(g) *Location:* As visual inspection during operation is not required, the tube can be entirely enclosed, out of sight, facilitating both electrical and roentgen-ray protection.

(h) *Operation:* This can be directly from a transformer without auxiliary rectifying device, thus making possible for many purposes a very simple outfit.

(i) *Long life.*

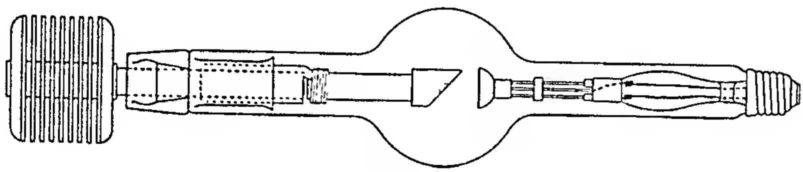


Fig. 6. Radiator-type tube.

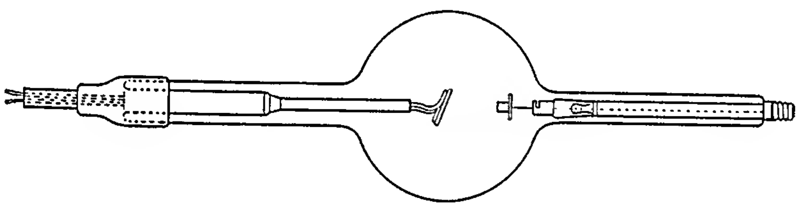


Fig. 7. Water-cooled therapy tube.

(2) *Various Forms:* Many forms of hot-cathode tube of the high-vacuum type have now been developed to cover a wide range of usefulness. They vary in size from that of an oil-immersed dental tube with a bulb diameter of 1 1/2 inches and a length of 4 inches, up to that of the 1,400,000-volt tube at the National Bureau of Standards (34), which is 12 inches in diameter and 24 feet long.

The "Universal" tube (Fig. 5) with a solid tungsten target is a form that has been used for both diagnostic and therapeutic purposes for many years. As its target may get very hot, it is intended to be operated only with rectified current.

Another typical design, for diagnostic work only, is a radiator-type tube (Fig. 6) built with a copper-backed tungsten target, that operates over a wide range of energy ratings and is capable of rectifying its own

current provided the energy used is not sufficient to heat the focal spot to a temperature at which appreciable electron emission would take place.

Still another type, with a high energy rating for continuous operation, is a water-cooled tube (Fig. 7) especially developed for therapeutic use.

A special form of therapy tube has been developed for internal body cavity work (12).

For use at very low voltages (say 1,000 to 10,000 volts) thin beryllium windows may be employed.

(3) *Current Control:* The electrons are emitted from a hot tungsten filament, and the tube can be so designed that the current flowing from cathode to anode is either emission limited or space charge limited. In the former case, over the operating range of voltage, all of the available electrons from the filament are used, and the milliamperage is, therefore, dependent only on filament temperature. In the latter case, the filament is always operated at a temperature in excess of that required to emit the desired number of electrons, and the milliamperage is limited by the negative space charge due to the electrons, the amount of this space charge being determined by the electron velocity and hence by the voltage used.

The tube used for the data contained in Figure 3, when operating with a filament current as high as 3.6 amperes, was evidently emission limited from about 50 kv. upward, while for lower voltages it was space charge limited.

For maximum flexibility, it is desirable to design the tube to be emission limited in order that any desired current can be used with any desired voltage. With a space charge limited tube, the lower the anode voltage, the less current can be made to flow through the tube.

With an emission limited tube the current changes very rapidly with filament temperature, as shown in Figure 3. This makes it desirable to have a constant source of voltage to heat the filament. Storage batteries were used at first, but have since been generally replaced by transformers for filament excitation. The effect of fluctuations in line voltage is minimized by some form of stabilizer, such as the Kearsley (13) or constant-current transformer type (14).

(4) *Control of Quality and Intensity of Radiation:* The hot-cathode tube, unlike its predecessor, permits of the independent control of the quality and intensity of roëntgen-ray output. The quality is determined primarily by the applied voltage and secondarily by wave form and target material. It is also somewhat dependent on the angle, referred to the tube axis, at which the roentgen rays are emitted. These conditions all being fixed, the intensity is simply proportional to the current.

The roentgen rays produced are in general of two kinds, those characteristic of the target material and those which are independent of target material and, like white light, include a considerable range of wave lengths. Of the latter, the *shortest* wave length, λ_0, bears the following simple relation to the voltage:

$$\lambda_0 = \frac{12340}{\text{voltage}}$$

in which λ_0 is expressed in Ångström units (1 Ångström $= 10^{-8}$ cm.). For practical purposes, the *effective* wave length can in general be considered to be about twice the minimum value.

In comparison with visible radiation, which lies between 4,000 and 7,000 Ångströms, roentgen rays in use today range in effective wave length from about 0.00025, corresponding to 100,000,000 volts, to 25.0 Ångströms, corresponding to about 1,000 volts. Table I gives the voltage range and the corresponding effective wave lengths of radiation employed for various medical purposes.

(5) *Radiation from Other than Focal Area:* In the hot-cathode high-vacuum tube, even with perfect focusing of the primary electrons, there is in general a considerable roentgen-ray production from the surface of the target outside of the focal area (15). This is due to high-velocity

TABLE 1: VOLTAGE RANGE AND EFFECTIVE WAVE LENGTH FOR MEDICAL PURPOSES

Application	Voltage	Effective Wave Length
Dental roentgenography	50,000 to 70,000	0.5 to 0.4 Å.
General roentgenography	30,000 to 100,000	0.8 to 0.24 Å.
Therapy	1,000 to 1,000,000	24.7 to 0.025 Å.

secondary electrons emitted from the focal spot. They cannot go, as in the gas tube, straight to the glass walls, as these are, in the high-vacuum tube, at relatively close to cathode potential. They must therefore return to the anode, where their impact gives rise to the roentgen radiation which may be observed, by means of a pinhole camera, as coming from other than the focal area. For diagnostic purposes this parasitic radiation would be troublesome if it were much more intense than it is. Its effect could, however, be reduced, if necessary, by special design.

(6) *Angular Distribution:* The intensity of the rays is dependent upon their direction with respect to that of the cathode rays which produced them, and the relation of these two quantities is strongly affected by the voltage used. At voltages much below a million it is customary, for most purposes, to use roentgen rays emanating from the face of the target, which it is convenient to designate as the "reflected rays," while with higher voltages the rays passing through the target ("transmitted rays") are more often employed. In the case of tubes intended for use in body cavities and employing relatively low voltages, transmitted rays are ordinarily used.

Penetrating power is also affected by direction of emission but not to so great an extent as intensity.

Measurement of the intensity of the reflected rays from a "Universal" tube (Fig. 5) showed (16) a maximum in close to the direction of the generally used "central ray," decreasing to half this value at an angle (measured around the girdle of the tube) of about 75 degrees on either side. This was with a voltage of 127,000. Petrauskas, Van Atta, and Myers (17), using the unfiltered "transmitted" beam from a target placed at right angles to the cathode rays, found at 2,350,000 volts maximum roentgen-ray intensity close to the central ray, dropping to half value at about 37 degrees from this direction. Dr. Kerst (18), working with the induction electron accelerator at 20,000,000 volts, found the intensity dropping from maximum to half value in about 4 degrees. With the 100,000,000-volt induction electron accelerator operating at full voltage, the corresponding angle is only 1 degree (19).

(7) *Efficiency of Roentgen-ray Production:* The efficiency is directly proportional to the atomic number of the target metal and increases rapidly with voltage. Rutherford and Barnes (20), operating a hot-cathode tungsten-target tube from a static machine, obtained at 96,000 volts an efficiency of transformation of cathode-ray energy into roentgen-ray energy of 0.2 per cent.

Recent measurements made by Petrauskas, Van Atta, and Myers (17) with the help of the large Van de Graaff static machine at the Massachusetts Institute of Technology show the following dependence of efficiency upon voltage, the rays being taken from a gold target and in the forward direction (that of the cathode rays) and corrected for absorption in the target.

Voltage in Millions	Efficiency (Measured)	Efficiency (From Theory)
2.35	10.4%	8.3%
1.63	5.8%	5.6%
0.90	3.0%	3.4%

(8) *Operation Self-Rectified:* Under normal conditions, current can pass through the tube in but one direction. If, however, any portion of the focal spot is allowed to become heated to the temperature of the cathode filament, on alternating current excitation, current will flow through the tube in both directions. The resulting electron bombardment of the cathode will raise its temperature, thus increasing the target bombardment and so

causing run-away. While, then, the tube may be satisfactorily operated from alternating current, serving as its own rectifier, with any given design the capacity of the tube is always greater when operating from a unidirectional source.

(9) *Limit to Allowable Energy Input:* Even with rectified current, the energy input must not be so high as to cause appreciable vaporization of the tungsten from the focal spot, for the tungsten vapor, by becoming ionized, may cause instability, signalized by rapid rise of current.

B. Tubes for Roentgenography

(1) *Considerations Affecting Target Design:* For the production of roentgenograms of the highest technical quality, the tube should be so designed and constructed as to permit the production of the greatest possible roentgen-ray intensity, consistent with satisfactory tube life, from a given size of focal spot. The target in most general use is the composite one developed earlier for the gas tube and having a tungsten facing of a certain thickness in good thermal contact with a large mass of copper. The copper with its high heat conductivity serves to take the heat away rapidly from the focal spot, distributing it to its large mass which serves as a reservoir, from which it can later escape by radiation and conduction before the next operation of the tube. The thickness of the tungsten facing will be chosen just sufficient to prevent the melting of the copper at its hottest point just behind the focal spot.

In this same connection, cathode design is also important, as it determines not only the size but also the distribution of energy over the focal spot. This last must be as uniform as possible, as, for a given area, the limit to allowable energy input will be set by the hottest part of the focal spot.

(2) *Power Supply:* For the maximum possible roentgen-ray intensity per unit of focal area, direct current at constant potential would be employed to operate the tube. As single-phase alternating-current high-voltage apparatus is much simpler, however, it is ordinarily used. With alternating-current high-voltage supply, the maximum available intensity per unit area is appreciably greater if an auxiliary rectifying device, such as a full-wave kenotron rectifier, is employed; here again, however, a simpler system, in which the roentgen tube rectifies its own current, is often used.

(3) *Line Focus:* In the line-focus tube (21, 22), as shown in Figure 8, a rectangular electron beam is used to provide a projected square focal spot in the useful roentgenographic direction. The gain obtainable by this method (23) is determined by the minimum angle of the target face with the direction of the useful beam that will provide adequate film coverage for the largest film at the minimum distance to be used. In general, a 20-degree angle has been found to be the most practical for

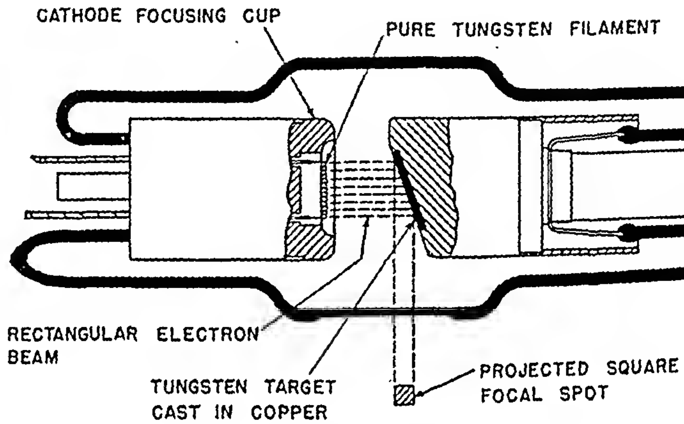


Fig. 8. Hot-cathode line-focus tube.

roentgenographic uses. For this, the gain over a 45-degree angle may be as much as threefold. In some special tubes 15 degrees is used and even 10-degree target angles have been employed. The gain for 15 degrees may be about fourfold, and for 10 degrees as much as fivefold. The coverage at 10 degrees is, however, so small that a minimum of 6 feet target-to-film distance should be used. There is, furthermore, this disadvantage in the use of so small an angle as 10 degrees, that the development, with use, of any considerable roughness of the focal area may cause serious loss of roentgen-ray intensity in the useful direction.

(4) *Variety of Focal Spot Sizes Desirable:* Various subjects for roentgenography may require widely different amounts of radiation, as well as different limits in time of exposure. To facilitate the revelation of as much detail as possible in all cases, tubes are made with a variety of focal spot sizes ranging from about 1 to 9 mm. For focal spots of these sizes the allowable loading of a tungsten target 3 mm. thick, cast in copper, varies from about 50 to 600 watts per square millimeter, depending on size of focal spot and time of exposure. Figure 9 gives safe values for tubes operating on single-phase, full-wave rectified 60-cycle current. The smaller focal spots will stand higher specific loadings because the surrounding tungsten is more effective in heat removal from them than in the case of larger focal areas.

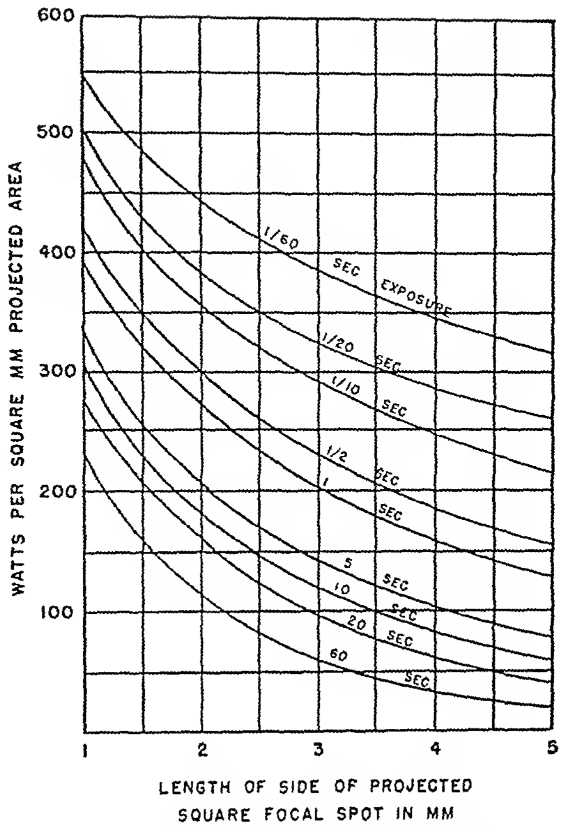


Fig. 9. Tungsten-target focal spot loading data: single phase, full wave, 60 cycles; line focus 20° target angle.

(5) *Double Focus:* To simplify the technic of roentgenography of the various parts of the human body, double-focus tubes are often employed. In these tubes, by means of a double cathode, either of two radically different sizes of focal spot may be used, the smaller to give fine detail in body extremities and the larger for thicker parts requiring more energy.

(6) *Rotating Target:* The loadings of a stationary target cannot safely exceed certain definite values. By rapid rotation of the target, however, relatively cold metal can be constantly advanced to take the electron bombardment, and so the permissible loadings can be greatly increased. Such rotation was suggested by R. W. Wood in 1897, and later by Rollins and Elihu Thomson. In 1915 Coolidge reported on experimental work with a tube in which the rotating target was supported by ball bearings and ran at 750 r.p.m., yielding a gain of two- or threefold in the amount of energy which could be carried on a given focal area.

The target is best rotated by means of an induction motor whose stator is without and whose rotor is within the tube and carries the target. A commercial tube embodying this principle and with a plain sleeve bearing was described by Bouwers (24) in 1929.

Ball bearings, to be used successfully, must be made of metal which is hard at the temperatures to which they are subjected in this application. This requirement is fulfilled by certain precipitation hardening alloy steels.

In our early ball-bearing rotating-target tubes the drastic heat treatment required for the exhaust removed the last trace of lubricant from the bearings. As a result, the friction was high and, to operate at all well, it was necessary that the bearings have appreciably more than the customary radial clearance, which made them very noisy. It has since been found that this difficulty can be overcome by coating the bearings either with a thin film of barium (26) or silver (25).

In the rotating-target tube shown in Figure 10 rotation is combined with the use of the line focus. The gain to be derived by rotation is shown in Figure 11 for various speeds (27).

In rotating-target tubes on the market today a speed of 3,000 to 3,500 r.p.m. is employed. The gain in loading as compared to a stationary-target tube varies with the exposure time and is about as the square root of the speed.

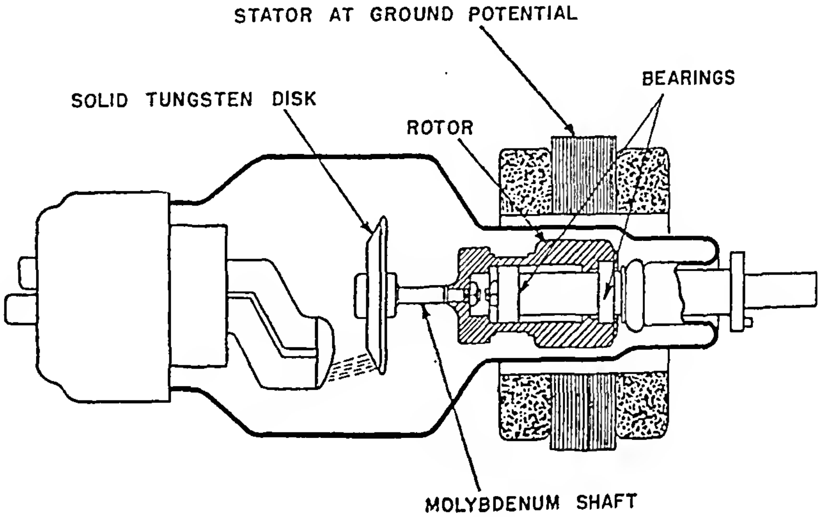


Fig. 10. Rotating target tube with stator in position.

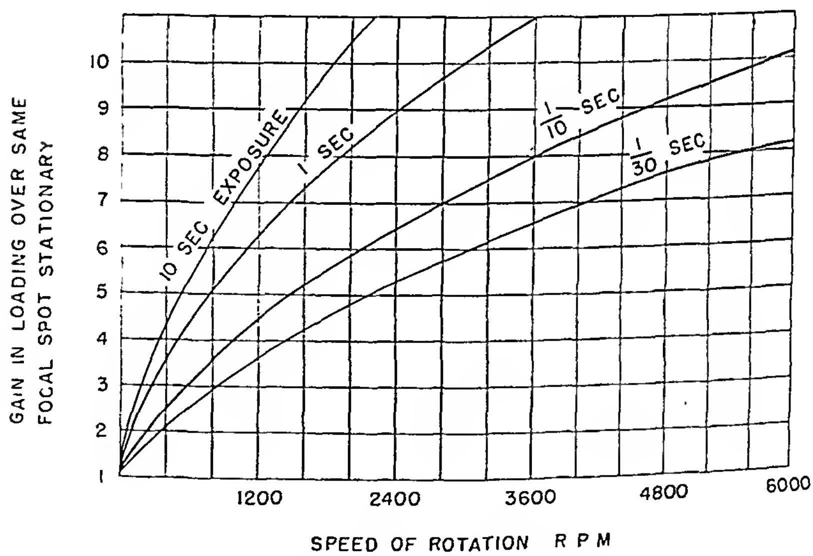


Fig. 11. Gain from rotation of target.

C. Tubes for Fluoroscopy

In the medical field the same tubes used for roentgenography are in general suitable for fluoroscopy, as the requirement

of the latter service have been considered and met in the design of roentgenographic tubes. Most medical fluoroscopy is done with a current of 2 to 5 ma. at voltages from 40 to 85 kv.p., depending upon the technic employed and the part of the body being studied. In this service the tube may be energized for a few seconds or for several minutes at a time.

For industrial fluoroscopic work, special tubes may be required, as currents of as high as 15 to 30 ma. at voltages of 85 to 250 kv.p. may be needed.

As the detail recognizable in fluoroscopy is not as great as in roentgenography, exact size of focal spot is not as important as in the latter service. For the requisite long time of operation, the total heat developed is considerable, and the anode must be capable of handling it.

In "spot-film" medical roentgenography the area to be delineated is chosen by fluoroscopy. In those cases, as of the stomach, where motion is involved, the time for making the exposure is chosen by the same means. Fluoroscopy is then rapidly followed by roentgenography, thus imposing heavy duty on the tube. This may necessitate, for cooling the target, the use of a blower or liquid circulating system.

D. *Tubes for Therapy*

(1) *General Considerations:* In therapy the main requisite is to provide a sufficiently large beam of the desired kind of radiation having essentially uniform intensity over its entire cross section. The skin-focus distance, dictated in general by depth-dosage considerations, ranges from about 25 to 100 cm., and the largest field to be covered is about 20 × 20 cm. The size of focal spot is relatively unimportant. Usually round, it varies from about 1/4 to 1 inch in diameter.

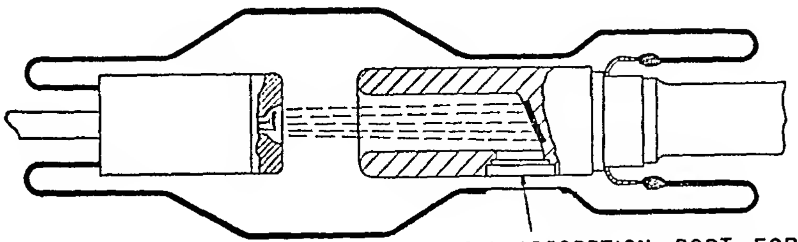


Fig. 12. Self-rectifying therapy tube with hooded anode construction.

Treatment periods range from several minutes up to as much as an hour in special cases, so that the duty of the tube for all practical purposes must be considered as continuous. This means that the main design problem in tubes for therapy concerns the removal of heat from the anode. This may be accomplished by using a solid tungsten target, as in Figure 5, and allowing this to heat up to a high temperature where it can radiate the requisite amount of energy, or a composite tungsten-copper target may be cooled by rapidly flowing water or oil. In the case of oil-immersed tubes a heavy anode stem may be employed to conduct heat out to the oil, where it may be dissipated by natural convection.

(2) *Superficial Therapy:* The voltage employed in superficial therapy may be as low as 5,000 or 10,000, in which case the radiation would not be transmitted to a useful extent through the ordinary glass envelope. For such work a thin window of beryllium metal may be employed.

(3) *Intermediate Therapy:* Therapy tubes for voltages in the neighborhood of 140,000 differ little, if any, from tubes intended for roentgenography.

(4) *Deep Therapy at Voltages from 200 to 400 kv.p.:* Voltages from 200 to 400 kv.p. make possible the treatment of the most deeply seated tumors in the body. Tubes produced today for these voltages have a thick-walled pyrex envelope to

avoid puncture. They usually are cooled by circulating oil in the back of the target and at 200 kv. may well carry as much as 10 or even 30 ma. They may be operated from either a rectified or unrectified current source. The performance of such tubes when operating directly on alternating current is considerably improved by the use of a hooded target, as shown in Figure 12. The presence of the hood reduces the number of secondary electrons emanating from the target and reaching the glass envelope, where otherwise their presence in sufficient number might lead to puncture.

For 400,000 volts, tube design is much the same as for 200,000 volts except that all physical dimensions have to be increased. At this voltage, less current is in general required, and at present 5 ma. is in common use.

(5) Deep Therapy at Still Higher Voltages: During the last few years much interest has been shown in the therapeutic use of voltages of a million or more. For such voltages, and even for much lower ones, the tube can to advantage be sectionalized (28) and provided with a multiplicity of hollow accelerating electrodes. This gives a more uniform gradient along the length of the tube and reduces dielectric stresses in the glass envelope. At the same time it serves to prevent the formation of troublesome field currents which may otherwise take place from the cathode, due to the stronger field which exists there in case only a single pair of electrodes is used. The accelerating electrodes are usually connected to suitable taps in the high-voltage source. With such high voltages the target may be so designed as to make possible the use of either the radiation coming through the target or that given off from the face. At these voltages the intensity is greater in the "transmitted" than in the "reflected" beam and the effective wave length is shorter.

Such tubes may either be operated while

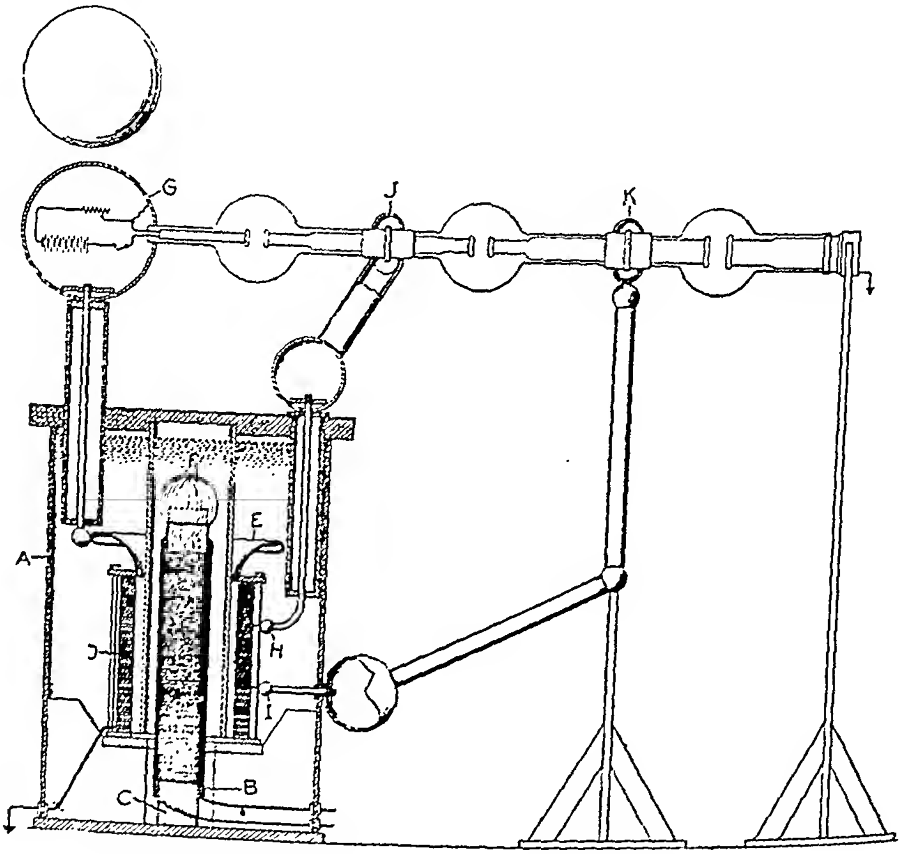


Fig. 13. Early experimental multisection tube.

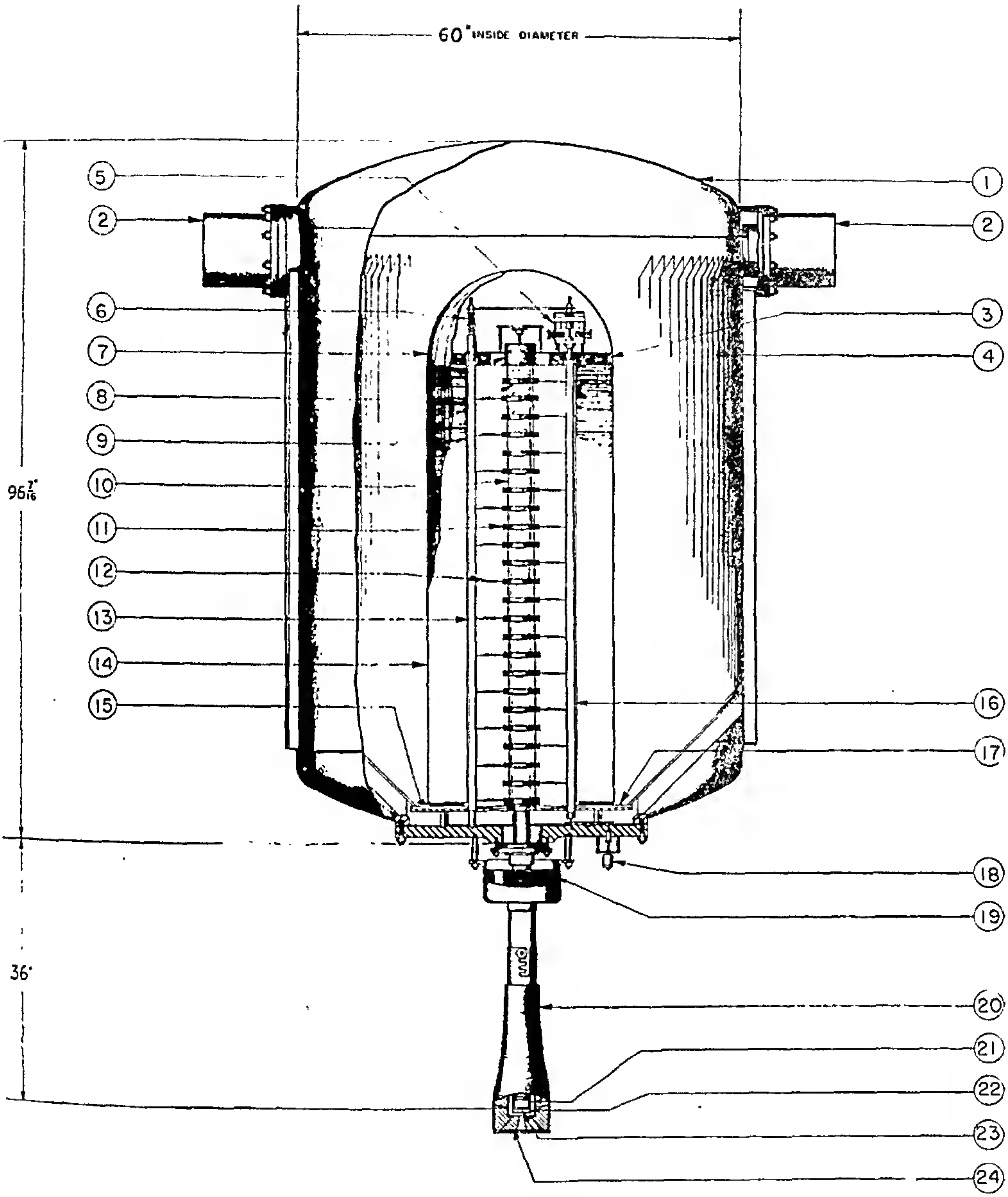


Fig. 14. Mobile two-million-volt roentgen-ray outfit.

1. Steel tank
2. Cooler
3. End turn filament coil
4. Laminated shield
5. Variable reactor
6. Spring for tie rod
7. Slotted brass shield
8. Cathode assembly
9. First intermediate electrode
10. Glass envelope
11. Shields around roentgen ray tube
12. Tap lead
13. Glass tie rod
14. Secondary coils
15. Primary winding
16. Insulating filament-control shaft
17. Laminated steel bottom
18. Filament control motor
19. Focusing coil
20. Lead shield
21. Water jacket
22. Extension chamber
23. Tungsten target
24. Lead diaphragm

undergoing continuous evacuation from a suitable pumping system or they may be sealed off. A diagram of an early experimental induction-coil installation is shown in Figure 13. This was followed by commercial transformer installations in which the tube consisted of a multiplicity of cylindrical glass sections cemented or sealed together and provided with hollow cylindrical accelerating electrodes.

With the advent of the low-frequency resonance transformer (29), it became possible to put the tube inside of the transformer. This facilitates the connection of the various accelerating electrodes to the transformer and at the same time provides electorstatic shielding for both the tube and the connecting leads.

An early one-million-volt example of this type of equipment was installed in 1939 at the Memorial Hospital in New York (29). It was stationary and arranged for therapeutic use with either the reflected or transmitted beam. It had a 12-section tube which was continuously pumped. A later similar one-million-volt outfit (30), developed originally for industrial roentgenography, is smaller, has a sealed-off tube, and can be operated in any position.

A similar outfit (31), also with sealed-off tube and operable in any position, has been developed for 2,000,000 volts. The cut-away drawing of Figure 14 shows the tube in position inside the high-voltage resonance transformer.

It seems entirely feasible by this method to go still higher, to perhaps as much as four or five million volts.

E. *Diffraction Tubes*

For roentgen-ray diffraction work it is desirable to have radiation which is as nearly as possible monochromatic. This is obtained by using not the general roentgen radiation, but that characteristic of the target material. As, for different purposes, different wave lengths are required, this necessitates the use of tubes with different target metals, as, for example, copper and molybdenum. The voltages used for these two metals are usually 30 to 35 kv. for copper and 35 to 45 kv. for molybdenum, and the characteristic wave lengths are 1.539 Å. for copper and 0.709 Å. for molybdenum. These radiations are usually taken out through thin beryllium windows (33). To increase the capabilities of the diffraction tube, it may be provided with a number of windows, thus making possible the simultaneous study of a corresponding number of specimens. Such a tube is shown in Figure 15.

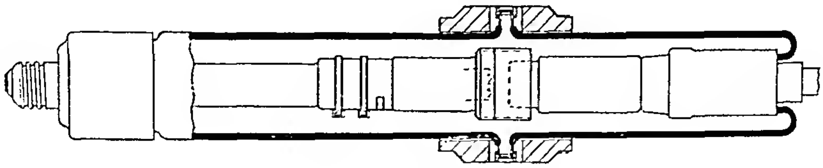


Fig. 15. Diffraction tube.

THE PROTECTION PROBLEM

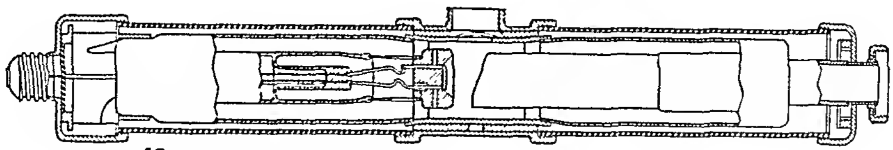
Protection must be provided from both the roentgen rays and the high voltage. This is accomplished much more readily with the modern type of tube than with its predecessor, and for two reasons: first, the modern tube can, for the same service, be much smaller than the gas tube; second, it does not need to be seen during operation.

A. Roentgen-Ray Protection: As roentgen rays are emitted in all directions from the front of the focal spot, lead or its equivalent is used either in the walls of the tube or in the tube enclosure to absorb all but the useful beam. The electrodes of the tube are usually sufficiently massive to guard against most of the radiation which would otherwise escape from the ends.

Roentgen-ray protection is readily secured in the Metalix tube (32) of the Philips Company, with its grounded metal envelope surrounding the central portion

(Fig. 16). An alternative construction is shown in Figure 17. The same result is also secured by the construction shown in Figure 18, in which the radiator-type tube of Figure 6 is provided with a two-piece, thick-walled shield of glass having a high lead content.

tube envelope and more particularly in 1,000,000- and 2,000,000-volt tubes in which the roentgen rays are transmitted through the target as well, roentgen-ray protection is to a great measure facilitated by surrounding this chamber with an adequate wall of lead.



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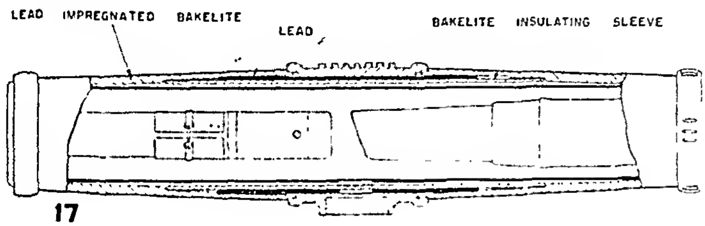

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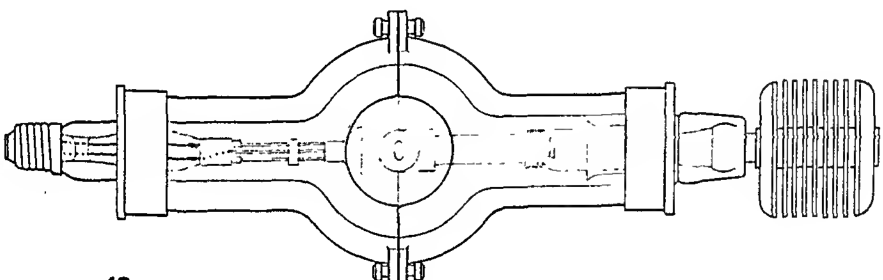

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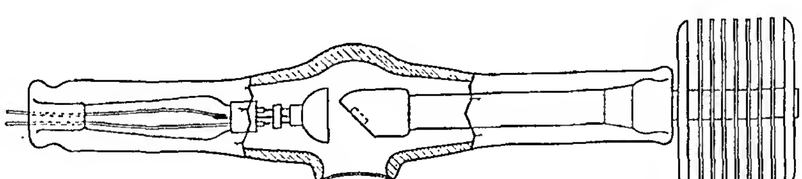

19

Figs. 16–19. Protected tubes. Fig. 16. Metalix tube. Fig. 17. Alternative construction of roentgen-ray protected tube. Fig. 18. Radiator tube in lead glass shield. Fig. 19. Roentgen-ray tube with vacuum envelope of protective lead glass.

The small tube of Figure 19, developed for medical diagnostic use with a portable outfit, derives its roentgen-ray protection from its very thick envelope of glass having a high lead content. The useful beam of rays is taken out through a lead-free glass window.

In tubes in which the target is located in a metal extension chamber attached to the

B. *Electrical Protection:* Full electrical protection is obtained by enclosing the entire high-voltage circuit in grounded metal. Two different methods are used:

One of these is illustrated by Figure 20, which shows a small roentgen tube together with filament transformer and high-tension transformer all in the same oil-filled metal case. Such a system is exten-

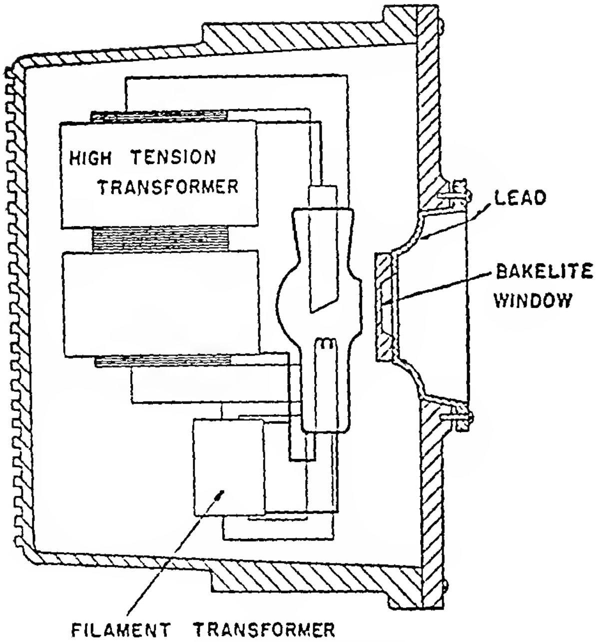

Fig. 20. Roentgen-ray tube and transformer in same oil-filled metal container.

sively used for dental work, therapy, and other applications. In some cases, as in the outfit shown in Figure 14, compressed gas is used in place of oil for the high-voltage insulation.

The other method of securing electrical protection consists in housing the tube in a grounded oil-filled metal enclosure, as shown in Figure 21, and connecting it to the high-voltage source by means of heavily insulated flexible metal-clad cable. For rapid medical roentgenography, this method is preferable to the former, as it permits the use of a powerful high-voltage source of rectified current while retaining relatively light weight in the part which has to be moved, namely, the tube and its enclosure.

With both systems, lead or its equivalent will be used around the tube, and the metal enclosure can be made not only to provide electrical protection but also to increase the roentgen-ray protection.

INDUCTION ELECTRON ACCELERATOR

For the production of roentgen rays corresponding to voltages in excess of a few million, the induction electron accelerator is today the most attractive looking device. It has proved successful in the 20,000,000- and the 100,000,000-volt sizes (18, 19) and can presumably be used for still higher voltages. The tube is a hot-cathode high-vacuum device consisting of a hollow toroid of glass or other insulating material about 18 inches in diameter for the 20,000,000-, and 6 feet in diameter for the 100,00,000-volt sizes. The electrons from a hot filament are electrostatically focused and are accelerated with some 20,000 volts or more in a direction tangential to the axis of the toroid. By means of a time-varying magnetic field they are further accelerated and focused and constrained to follow a circular path within the tube. In the case of the 100,000,000-volt machine they encircle the field 250,000 times in 1/240 second, receiving on an average a 400-volt push each time around. After traveling in this way in a circular path for about 800 miles and receiving the energy which they would have had if they had passed between two electrodes having a potential difference of 100,000,000 volts, they are caused to leave their circular orbit and impinge upon a tungsten target, where they produce roentgen rays. Or they may be caused to leave the circular orbit at any desired earlier time in the magnetic cycle, thus producing roentgen rays corresponding to any voltage up to 100,000,000.

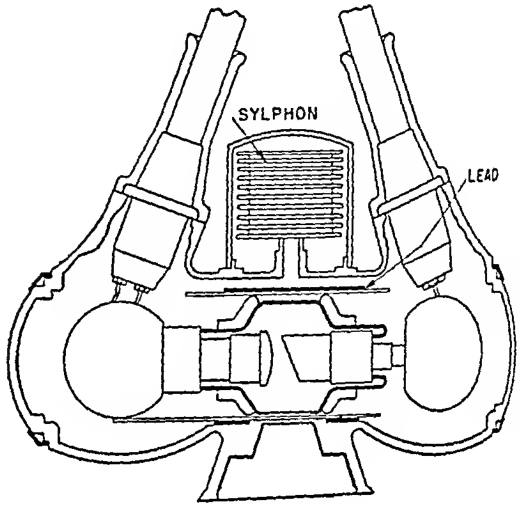

Fig. 21. Roentgen-ray and electrically protected tube enclosure.

The electron current in the beam is very low compared with that which has ordinarily been used in roentgen tubes, and of the order of a microampere, depending to a great extent on the frequency employed for the time-varying magnetic field.

The tubes may be built either as unitary structures or in sections cemented together and continuously pumped. The 100,000,000-volt tube is shown in Figure 22. It consists of 16 pie-shaped sections of heat-treated Pyrex glass having an elliptical cross section 8 × 4 7/8 inches. The ends of the sections are ground flat and smooth and to the correct angle, and the joints, coated on the outside with glyptal paint, are vacuum tight.

The induction electron accelerator, as a multimillion volt roentgen-ray source, will be extensively used in scientific research and should also find therapeutic and industrial applications.

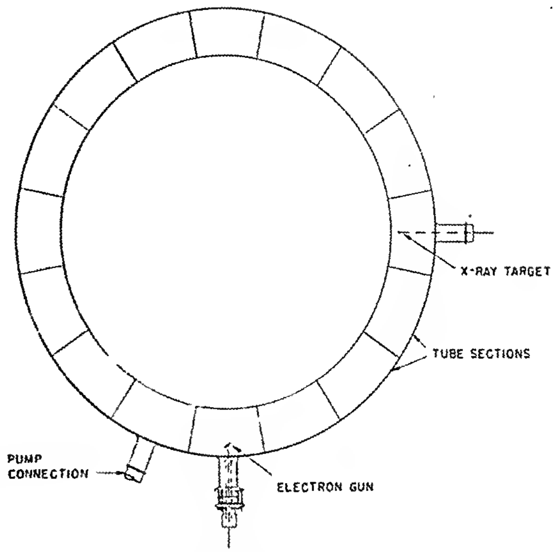

Fig. 22. Induction electron accelerator tube for 100,000,000 volts.

SUMMARY

During the fifty years since Röntgen's great discovery, the roentgen tube, from a very uncertain and relatively feeble source of radiation, has been developed into a powerful precision tool of great stability, flexibility, and ease of control, permitting of the accurate reproducibility of results and capable of operation over a wide range of current and voltage. In the diagnostic field, definition for a given speed has been, through the years, greatly improved. For therapeutic work, the high-voltage rays now obtainable make possible the treatment of deep-seated lesions. The various industrial applications make use of the entire range of wave lengths which can be derived from the tube, at least corresponding to voltages up to a few million. The gradual increase which has taken place in the allowable voltage has been attended by a corresponding extension in the range of usefulness of the rays in industry. Much roentgen-ray protection can now be built into the tube itself, and the modern tube lends itself readily to the attainment of complete electrical protection. From the point where only an expert, with years of experience, could get the most out of it, the tube has come to be as easy to operate as an incandescent lamp.

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1895  1945

The Development of Roentgen Diagnosis

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THE DISCOVERY of a new type of radiation by Wilhelm Conrad Röntgen in 1895 had a profound impact on science in general and on the practice of medicine in particular; not the least of its revolutionary effects was felt in the field of diagnosis. A new page in the history of medicine was written with that epoch-making discovery. The writing on the first pages may have been hesitant and irregular, but here and there, even during the first few years, can be observed broad, bold strokes that were prophetic of the advances that were to come.

The opinions as to the usefulness of Röntgen's rays in medical practice among the investigators and authorities in medicine in 1896 varied from extreme skepticism to surprising optimism. Indeed, it is a remarkable and astonishing phenomenon that the possibilities of x-ray diagnosis were so quickly and enthusiastically received. Contemplating the natural and beneficent conservatism which most medical men exhibit toward any new departure in medical science, one may well inquire into the reasons for the relatively rapid manner in which x-rays were applied to medical diagnosis. Within one month after the announcement of the discovery of a penetrating radiation which affected a photographic plate, patients were already being examined by this means. Experiments were being undertaken for improvement of equipment and technic, and efforts were even then under way to provide a means of contrast for demonstration of the soft tissues. It is doubtful whether anywhere in the annals of medical science can such a rapid acceptance of a completely new discovery be found.

The reasons for this unprecedented reception, in so brief a time, of a new medium for diagnosis in medicine are not difficult to uncover, and it may be of some interest to review them, for they are equally potent today. First of all, the nature of the discovery was such that the experiments could be readily repeated and the facts demonstrated visually, without delay and without cavil. Fortunately, apparatus such as Röntgen used was readily available all over the world. With a few simple directions it was possible to reproduce immediately the phenomena which he had so clearly described. By its very nature, then, the discovery was demonstrable of proof even to the most skeptical or hypercritical scientific mind. Furthermore, Röntgen had worked out in such detail the salient facts about this new medium that it was relatively simple to understand the potentialities of its application.

In the minds of medical men a new horizon was discovered. The possibility of submitting to visual inspection, in the living subject, structures which hitherto could be seen only in the surgery or on the autopsy table was so attractive—yes, even so exciting—that the impulse toward investigation and experimentation was well-nigh irresistible. Confined to the lesser senses of perception, touch, and sound, with the visual senses restricted to limited use in an indirect way, the medical diagnostician had always labored under great disabilities. The results of his studies were not inconsistent with such handicaps, as any comparison of medical diagnoses with autopsy findings, even during the second decade of this century, will amply attest. The opportunity of performing a veritable *autopsia in vivo* must have been dazzling to the physician who appreciated fully the present limitations of his methods and the possibilities of the new procedure. The importance of visual testimony has been emphasized in the aphorisms of many lands; the physician, like other human beings, places greater reliance upon ocular

perception than on the impressions gained from any other sensory organ. It is no wonder, therefore, that efforts toward improving and utilizing this medium began so early and were pursued with such determination.

The early history of medical progress in the utilization of Röntgen's discovery and much of the literature of the earlier periods has already been splendidly dealt with in a number of articles and books, from which the author has borrowed freely (26, 27, 66, 80, 109). It is not intended, within the limitations of this paper, to review all the advances in roentgen diagnosis over this half century in any detail or with any effort at literal completeness. Rather is it the purpose of this article to point out in broad outline the successive steps which have been taken to bring roentgen diagnosis to its present important place in the medical armamentarium. It seems unnecessary to stress the present position of x-ray examination in medical practice. Suffice it to say that, entirely aside from routine examinations, the scope of x-ray examination is so wide that approximately 80 per cent of patients in hospitals and 70 per cent of those seen in outpatient clinics will be submitted to some form of roentgen study at some period in the course of their illness. Furthermore, routine examination of the thorax is becoming so widely adopted, at least in hospital practice, that eventually all admissions to all hospitals will entail x-ray examination of one kind or another. That such practice may eventually be applied to the gastro-intestinal tract as well is not idle speculation but a real possibility. The importance of x-ray diagnosis cannot, therefore, be overemphasized.

In any discussion of the development of roentgen diagnosis a number of phases must be considered. There is, first, the evolution of x-ray equipment, which is being presented elsewhere in this issue of RADIOLOGY. There is the technic of radiography, also a separate subject in itself. In addition to the developments in these two technical fields, advances in roentgen diagnosis may be considered from the point of view of the evolution of contrast media and their application, the methods of x-ray examination, the roentgen signs of various injuries and disease processes, and the expansion and elaboration of the specific criteria for the x-ray diagnosis of various diseases and their differentiation from normal and other abnormal states. In the latter category come the descriptions of the roentgen anatomy of various organs, both normal and abnormal, and the roentgen signs of specific disorders of these organs.

EVOLUTION OF CONTRAST MEDIA

In the history of medicine there is nowhere a more fascinating chapter than that which relates the story of the introduction and amplification of various contrast media for roentgen diagnosis. It was at once apparent to Röntgen himself and, shortly thereafter, to the medical colleagues to whom he first communicated the results of his research, that the nature of any tissue would determine the degree of its opacity to the x-rays. Because in the early experiments only the bones were clearly visible, and in later studies metallic objects within the tissues were also observed, it was assumed that the efficacy of the method would be limited to the skeleton. For some reason investigation of the thorax was not immediately undertaken, but efforts to make visible the esophagus and the gastro-intestinal tract followed these first halting steps with great rapidity. Early in 1896 metallic sounds were introduced into the esophagus of a cadaver; shortly thereafter lead solutions were injected to make this structure dense enough so that contrast between itself and the surrounding tissues could be achieved. Thus the beginning of a new method of study of the internal organs was initiated.

The development of the use of contrast media in roentgen diagnosis is portrayed to some degree in graphic form in Figures 1 and 2, which have been adapted and elaborated from two figures previously published (173). It should be noted that

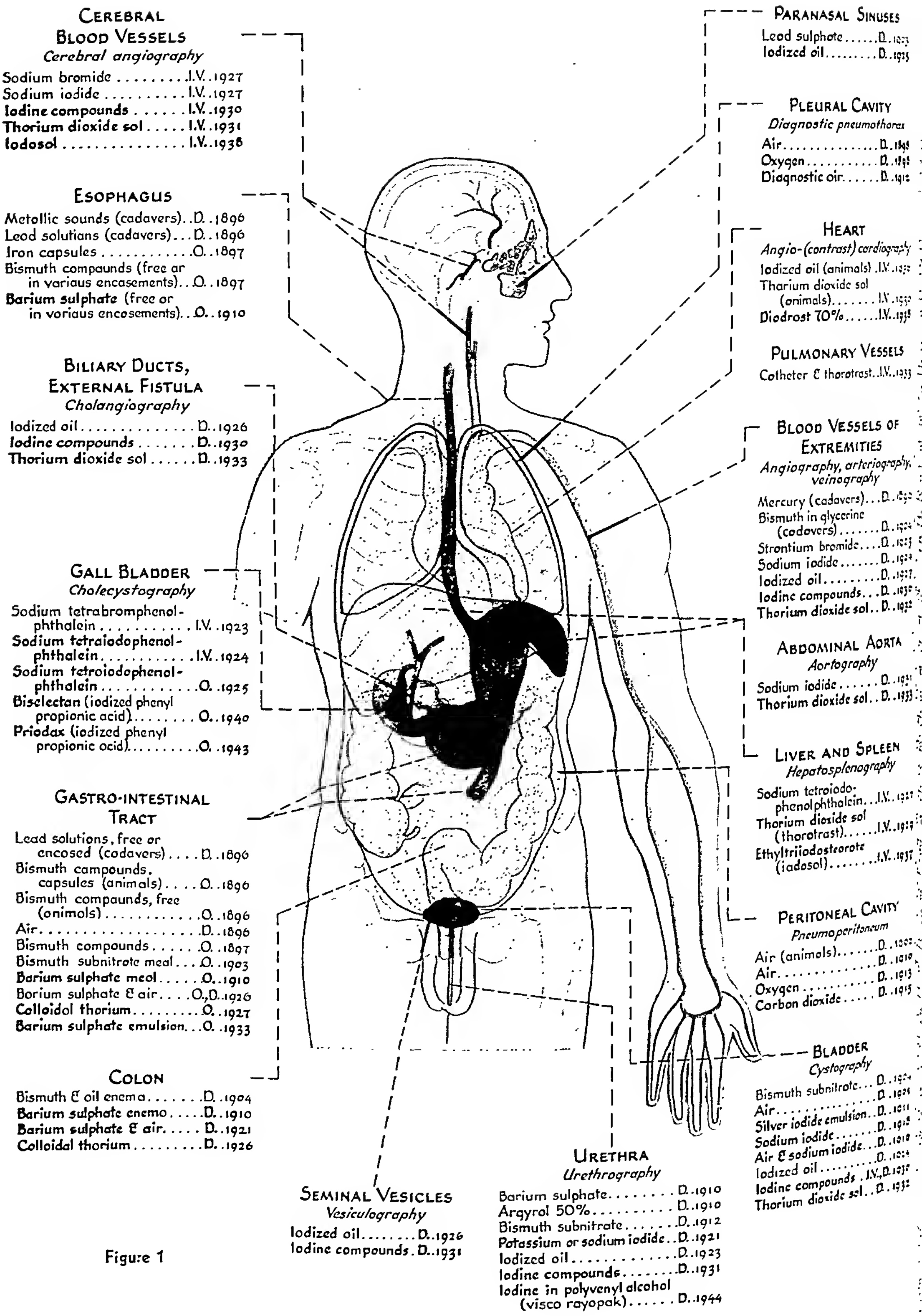
not all of the innumerable variations of the common contrast media have been included in the figures; no doubt some minor contributions may have been omitted. Furthermore, no effort has been made to assign credit to the originator of each procedure. Such details are left to the medical historian, who can best assess the records. By presenting the approximate dates, it is possible to indicate roughly the chronology of the evolution. In the diagrams the obsolete materials are indicated by the light-faced type, while the obsolete procedures are indicated directly. The symbol "D" indicates the direct method of introduction, through a tube, a catheter, needle, or other injection method, while the symbol "O" refers to the oral ingestion of the substance, "I.V" to intravenous introduction, and "I.S" to the intraspinal route. It should be noted that the term "iodine compounds" is used, for purposes of brevity, to refer to the iodine-pyridine derivative (Neo-Iopax) and the iodine preparation (Diodrast), to sodium ortho-iodo-hippurate (Hippuran), as well as to the other organic iodine compounds such as Selectan, Uroselectan, Skiodan, Iopax, Abrodil, Perabrodil, Tenebryl, many of which have related chemical structures, although differing specifically in certain important respects. It may also be noted that Biliselectan and Priodax are trade names for beta(3,5 di-iodo-4-hydroxy-phenyl) alpha phenyl propionic acid. The term iodized oil includes Lipiodol, Iodochloral, Iodipin, Campiodol, and other media of similar nature.

It may be well to review briefly the details of the application of the contrast medium principle to the digestive tract. Perhaps the first efforts to make roentgenologically visible the esophagus in the living subject were by means of capsules of reduced iron and small rubber bags containing lead solutions (91). These were not especially successful and it was, no doubt, the original work of Cannon (33) on cats, followed by his work with Williams (221) on man, that gave the real beginnings to gastro-intestinal radiology. It should be noted that Leonard (129), and later Roux and Balthazard (179), followed closely with the same purpose in mind. Rumpel (182) used bismuth in the esophagus in 1897.

Such efforts were fragmentary and left no great impression until Rieder (172) in 1903 formulated the bismuth meal which, with various modifications, remained the standard contrast medium for oral administration in the roentgen study of the digestive tract for some years. At a later time barium sulfate was substituted because of its relative cheapness and more inert character. A great variety of vehicles for the salts were proposed and many used, but there have been no substantial changes in the medium itself since Bachem and Günther (8) described their barium meal. Many variations of the suspending mixture have been instituted, particularly for the more adequate demonstration of the mucosal pattern of the intestinal tract. At present the majority of experienced roentgenologists follow the lead of Cole (52) and others by using a simple water-barium mixture; certain emulsions of barium with gelatine or other colloidal materials are occasionally desirable. The introduction of gas into the stomach, either by injection through a tube, by simple air swallowing, or by chemical reaction such as occurs with Seidlitz powders is sometimes of value, although a simpler procedure is to have the patient swallow a carbonated drink. If barium sulfate is also used, a double contrast is produced, which may be of great value in the diagnosis of tumors of the cardiac end of the stomach.

In the case of the esophagus, many devices have been advocated to procure slow passage and good dilatation of the structure. Thus very thick mixtures, large capsules containing barium sulfate, sausage casings stuffed with barium sulfate mixture, and many other encasements have been advocated. Many of these have an important place under particular circumstances.

The examination of the colon by direct injection of bismuth subnitrate with oil,



Cerebral Blood Vessels
Cerebral angiography
Sodium bromide . . . . I.V. . 1927
Sodium iodide . . . . I.V. . 1927
Iodine compounds . . . . . . I.V. . 1930
Thorium dioxide sol . . . . . I.V. . 1931
Iodosol . . . . I.V. . 1938
Esophagus
Metallic sounds (cadavers) . . D. . 1896
Lead solutions (cadavers) . . . D. . 1896
Iron capsules . . . . O. . 1897
Bismuth compounds (free or in various encasements) . . O. . 1897
Barium sulphate (free or in various encasements) . . O. . 1910
Biliary Ducts, External Fistula
Cholangiography
Iodized oil . . . . D. . 1926
Iodine compounds . . . . D. . 1930
Thorium dioxide sol . . . . . . D. . 1933
Gall Bladder
Cholecystography
Sodium tetrabromphenol-phthalein . . . . I.V. . 1923
Sodium tetraiodophenol-phthalein . . . . I.V. . 1924
Sodium tetraiodophenol-phthalein . . . . O. . 1925
Biselectan (iodized phenyl propionic acid) . . . . O. . 1940
Priodax (iodized phenyl propionic acid) . . . . O. . 1943
Gastro-intestinal Tract
Lead solutions, free or encased (cadavers) . . . . D. . 1896
Bismuth compounds, capsules (animals) . . . . O. . 1896
Bismuth compounds, free (animals) . . . . O. . 1896
Air . . . . D. . 1896
Bismuth compounds . . . . . O. . 1897
Bismuth subnitrate meal . . . O. . 1903
Barium sulphate meal . . . . . O. . 1910
Barium sulphate & air . . . . O., D. . 1926
Colloidal thorium . . . . O. . 1927
Barium sulphate emulsion . . . O. . 1933
Colon
Bismuth & oil enema . . . . . . D. . 1904
Barium sulphate enema . . . . D. . 1910
Barium sulphate & air . . . . . D. . 1921
Colloidal thorium . . . . D. . 1926
Seminal Vesicles
Vesiculography
Iodized oil . . . . D. . 1926
Iodine compounds . D. . 1931
Urethra
Urethrography
Barium sulphate . . . . D. . 1910
Argyrol 50% . . . . D. . 1910
Bismuth subnitrate . . . . . . D. . 1912
Potassium or sodium iodide . . D. . 1921
Iodized oil . . . . D. . 1923
Iodine compounds . . . . D. . 1931
Iodine in polyvenyl alcohol (visco rayopak) . . . . . D. . 1944
Paranasal Sinuses
Lead sulphate . . . . . . D.
Iodized oil . . . . D. . 1925
Pleural Cavity
Diagnostic pneumothorax
Air . . . . D.
Oxygen . . . . D.
Diagnostic air . . . . . . D.
Heart
Angio-(contrast) cardiography
Iodized oil (animals) . I.V.
Thorium dioxide sol (animals) . . . . I.V.
Diodrast 70% . . . . . . I.V.
Pulmonary Vessels
Catheter & thorotrast . I.V. . 1933
Blood Vessels of Extremities
Angiography, arteriography, veinography
Mercury (cadavers) . . . D.
Bismuth in glycerine (cadavers) . . . . D.
Strontium bromide . . . . D.
Sodium iodide . . . . D.
Iodized oil . . . . D.
Iodine compounds . . . D.
Thorium dioxide sol . . D.
Abdominal Aorta
Aortography
Sodium iodide . . . . . . D.
Thorium dioxide sol . . D. . 1933
Liver and Spleen
Hepatosplenography
Sodium tetraiodo-phenolphthalein . . . I.V.
Thorium dioxide sol (thorotrast) . . . . . . I.V.
Ethyltriiodostearate (iodosol) . . . . I.V. . 1937
Peritoneal Cavity
Pneumoperitoneum
Air (animals) . . . . D.
Air . . . . D. . 1910
Oxygen . . . . D. . 1913
Carbon dioxide . . . . . D. . 1915
Bladder
Cystography
Bismuth subnitrate . . . D.
Air . . . . D.
Silver iodide emulsion . . D. . 1911
Sodium iodide . . . . D.
Air & sodium iodide . . . D. . 1918
Iodized oil . . . . D.
Iodine compounds . I.V., D.
Thorium dioxide sol . . D.

Figure 1

in the form of an enema, was first practised by Schüle (189) in 1904. The first mention of the use of barium sulfate in the colon seems to have been in 1911 (86). In 1921, Laurell (128) suggested the reinflation of the colon with air after ingestion of the barium meal; Fischer (71) gave a barium enema and, after its evacuation, reinflated the bowel with air, thus introducing the double contrast enema which has been popularized by Weber (215) in this country. Obviously, the colon is also examined after the ingestion of the barium meal by the oral route.

The institution of a procedure by which contrast substances were introduced into an organ of low density led promptly to further investigation in other fields, notably the urinary tract. The first experiment in this direction was undertaken by Tuffier (207), who introduced into the ureter a catheter rendered radiopaque by impregnation with lead. No effort to inject any fluid substance, however, was made until 1904, when Klose (119) introduced a bismuth suspension through a ureteral catheter with the unfortunate result that the material could not be easily evacuated. In 1906 colloidal silver (212) was first used. Following that time a great variety of media were introduced and discarded until the organic iodine compounds came into general use for both excretion urography and for retrograde procedures. Sodium iodide became the most commonly used medium to be introduced directly into the ureters and kidney pelves; brilliant results in the delineation of the normal and diseased kidney were obtained. So important has roentgen examination become in urologic practice that it now represents a major portion of the urologist's diagnostic procedures.

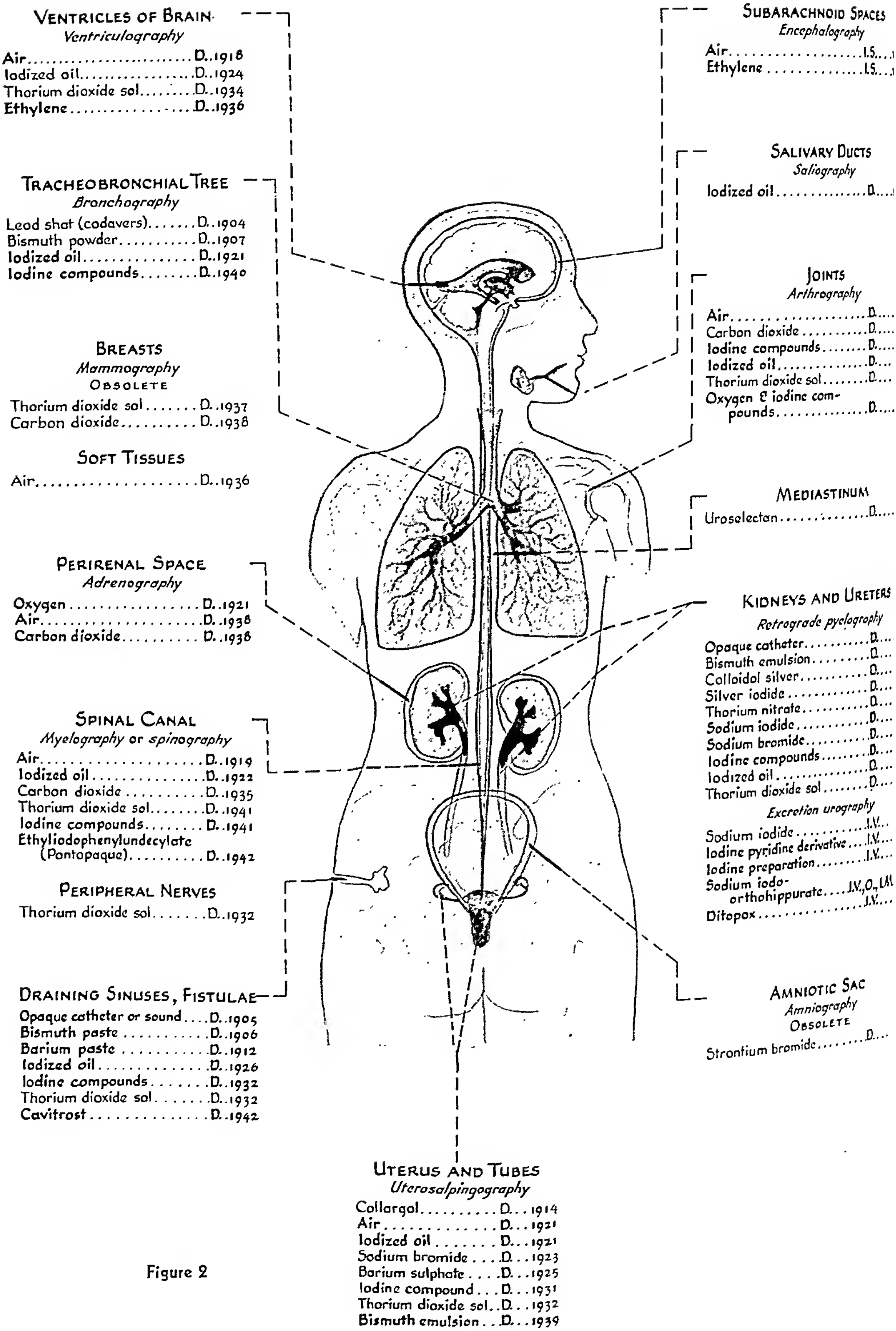
The direct injection of solutions of heavy salts into the bladder followed as a matter of course, and a wide variety of substances came into use for cystography. Here, too, largely through the work of Pfahler (161), the use of air as well as a substance opaque to the x-rays was evolved, and the double-contrast procedure using air and sodium iodide is a standard, important practice today. The examination of the urethra by means of various substances such as barium sulfate and potassium iodide was also undertaken.

It is evident that there was early realization of the salient fact that substances of lower x-ray density than the surrounding medium could be used almost as well as those of greater density. Thus the injection of air into the stomach as a contrast medium was tried very early, albeit with little success. It is notable that therapeutic pneumothorax was introduced about 1898, using both air and oxygen, but it was not specifically instituted for diagnostic purposes until Brauer (25) in 1912 injected air to differentiate the lung from the pleura by means of roentgen examination. Kelling (113), in 1902, injected air into the peritoneal cavity of animals and made direct vision studies. It was Jacobaeus (108), however, who first applied the same principle to man as a method of diagnosis in abdominal conditions and established the procedure of pneumoperitoneum, using air as a medium. Weber (214) used oxygen and was the first to make roentgenograms with this aid. Carbon dioxide was introduced later. Stewart and Stein (199), Carelli and Canévari (34), Sante (185), and numerous other investigators pursued the method, which has, however, fallen into some disuse (140). In occasional situations it is of great value and can be accomplished without danger.

The use of gases as contrast media has

Fig. 1. Development of Contrast Media for Roentgen Diagnosis

A diagrammatic representation of the chronological evolution of the contrast materials used for roentgen diagnosis. Only certain of the body systems and organs are shown in this postero-anterior projection. The name of the procedure, the name of the material, the year it was first used, and the method of introduction are given. Symbols are as follows: D. Direct injection by needle, catheter, or tube. O. Oral route. I.V. Intravenous route. Obsolete contrast media are indicated by light-faced type; media still in use by heavier type. Adapted from Figure 4, Outline of Roentgen Diagnosis (173).



Ventricles of Brain
Ventriculography
Air....D..1918
Iodized oil....D..1924
Thorium dioxide sol....D..1934
Ethylene....D..1936
Tracheobronchial Tree
Bronchography
Lead shot (cadavers)....D..1904
Bismuth powder....D..1907
Iodized oil....D..1921
Iodine compounds....D..1940
Breasts
Mammography
Obsolete
Thorium dioxide sol....D..1937
Carbon dioxide....D..1938
Soft Tissues
Air....D..1936
Perirenal Space
Adrenography
Oxygen....D..1921
Air....D..1938
Carbon dioxide....D..1938
Spinal Canal
Myelography or spinography
Air....D..1919
Iodized oil....D..1922
Carbon dioxide....D..1935
Thorium dioxide sol....D..1941
Iodine compounds....D..1941
Ethyliodophenylundecylate
(Pontopaque)....D..1942
Peripheral Nerves
Thorium dioxide sol....D..1932
Draining Sinuses, Fistulae
Opaque catheter or sound....D..1905
Bismuth paste....D..1906
Barium paste....D..1912
Iodized oil....D..1926
Iodine compounds....D..1932
Thorium dioxide sol....D..1932
Cavitrost....D..1942
Uterus and Tubes
Uterosalpingography
Collargol....D...1914
Air....D...1921
Iodized oil....D...1921
Sodium bromide....D...1923
Barium sulphate....D...1925
Iodine compound....D...1931
Thorium dioxide sol..D...1932
Bismuth emulsion..D...1939
Subarachnoid Spaces
Encephalography
Air....I.S....
Ethylene....I.S....
Salivary Ducts
Saliography
Iodized oil....D....
Joints
Arthrography
Air....D....
Carbon dioxide....D....
Iodine compounds....D....
Iodized oil....D....
Thorium dioxide sol....D....
Oxygen & iodine com-
pounds....D....
Mediastinum
Uroselectan....D....
Kidneys and Ureters
Retrograde pyelography
Opaque catheter....D....
Bismuth emulsion....D....
Colloidol silver....D....
Silver iodide....D....
Thorium nitrate....D....
Sodium iodide....D....
Sodium bromide....D....
Iodine compounds....D....
Iodized oil....D....
Thorium dioxide sol....D....
Excretion urography
Sodium iodide....I.V....
Iodine pyridine derivative....I.V....
Iodine preparation....I.V....
Sodium iodo-
orthohippurate....I.V.,O.,I.M.
....I.V....
Ditopox....
Amniotic Sac
Amniography
Obsolete
Strontium bromide....D....

Figure 2

derived a much wider application in a variety of directions. The injection of air into the perirenal tissues was first introduced in 1921, by Carelli and Sordelli (35) but was later abandoned. Owing to the natural contrast afforded by the perirenal fat, such good delineation of the kidneys could be obtained by modern technics that the addition of a contrast substance seemed unnecessary. New demands, however, for the roentgen demonstration of the adrenal glands have stimulated a revival of the procedure, and perirenal insufflation (adrenography) has thus been re-established for the diagnosis of hyperplasia and tumors of the adrenals.

The most important contribution in the field of low-density contrast media was Dandy's (58) proposal to inject air by needle directly into the ventricles of the brain through a trephine opening in the skull. This was followed shortly by his description (59) of the procedure of encephalography using the intraspinal route. Perhaps the most important agencies in the diagnosis of cerebral lesions were thus established, in 1918 and 1919, and have persisted with but minor changes in technic up to the present time. Ethylene has been substituted for air (153), and improvements in the methods of introduction of the gas, position of the patient, and manipulation of the head have been added, but the fundamental principle has remained.

It is of some interest to observe that as early as 1903, Weil (216) attempted to demonstrate the paranasal sinuses more clearly by injecting lead sulfate. This was abandoned, but the procedure of contrast study of the sinuses was later revived when a more suitable medium was obtained. Similarly bronchography was attempted by Jackson as early as 1907, by the insufflation of bismuth powder. He reported it in 1918 (107) and Lynah and Stewart (136) likewise experimented with this material. Jackson's procedure was not pursued because of the unsatisfactory character of the contrast medium.

Other early and important experiments should be noticed. Hickey (95), in 1904, injected a bismuth glycerin suspension into the arteries of cadavers, this being the first reported attempt at angiography. He also introduced lead shot into the bronchial tree of the cadaver for purposes of anatomical study. Beck (14), in 1906, made a bismuth paste for rendering draining sinuses and fistulae opaque to x-rays.

The formulation of an iodized oil (Lipiodol) by Sicard and Forestier (192) in 1921 was an important event in the onward march of roentgen diagnosis. They did not make any radical departure from the previous methods of introduction of the contrast medium, but their experiment was the first successful attempt to synthesize a compound whose properties would make it particularly suitable for roentgen exploration of internal organs. It was relatively non-irritant and had a high degree of x-ray opacity. While it was absorbed so slowly that it was non-toxic, complete absorption eventually occurred. Its viscosity was both an advantage and disadvantage.

The production of iodized oil permitted the establishment of bronchography (72), than which there is scarcely a more important procedure in the diagnosis of chronic pulmonary diseases. The oil was promptly put into use, also, for myelography (193) and has remained the standard medium for both purposes until very recent years. Of all the contrast media, iodized oil is used in more parts of the body than any other. It has been applied in the urethra, the seminal vesicles, the paranasal sinuses, the uterus and tubes, in external biliary fistulae, and for draining sinuses and other fistulae. It has been used in other organs but not as satisfactorily as are other media.

Fig. 2. Development of Contrast Media for Roentgen Diagnosis

The body systems and organs not exhibited in Figure 1 are shown in this antero-posterior projection. The additional symbol I.S. designates the intraspinal route. Obsolete procedures are so indicated specifically. Adapted from Figure 5, Outline of Roentgen Diagnosis (173).

The success of x-ray examination of the paranasal sinuses, while usually reasonably satisfactory as a result of natural contrast, can in some cases be greatly enhanced by the introduction of a dense material, and iodized oil is admirably suited for this purpose. Reverchon and Worms (171), in 1925, first proposed its use, administering it directly by means of a cannula in the ostium of the sinus. Later Proetz (166, 167) described an inhalation method which had the advantage that it gave a test of function as well. The increased contrast between the cavity of the sinus and its bony wall, together with observations of the time of excretion of the medium, adds materially to the diagnostic findings.

In the same way, iodized oil has been injected into the salivary ducts (159) for the demonstration of occlusion or ruptures, and in such situations it is an occasionally useful device. The urethra has also been examined in this fashion, but here a variety of contrast media have been advocated. Most recently Coe (49) has used a preparation of iodine in vinyl alcohol, called Visco-Rayopak, which he has found even more satisfactory than the others. The seminal vesicles likewise may be outlined satisfactorily by the injection of iodized oil, with consequent improvement in the diagnosis of the diseases of these organs.

Further elaboration of the employment of contrast media in the x-ray diagnosis of diseases of the tracheobronchial tree and lungs seems justified in the light of the importance of this application. Here again, Sicard and Forestier's production of an iodized oil made a new procedure of inestimable value possible. Since that time, many modifications of the material have been made for purposes of bronchography; the only radical departure was Fariñas' (68) description of the use of an organic iodine compound in 1940. The major advances have related themselves to the methods of application, which vary widely even today. The material was originally introduced by means of a laryngeal tube, then by a needle thrust through the cricoid cartilage, then directly through the bronchoscope, then through a catheter placed in the trachea by a variety of means. The introduction of a passive method for the inspiration of the oil into the bronchial tree led to a sharp rise in the usefulness of the procedure, since it could be so employed without instrumentation. At present, one of the two most commonly used methods is the passive procedure; that is, having the patient aspirate the material dropped along the back of the tongue after anesthetization of the pharynx and larynx. In the other method, a catheter is introduced into the trachea or into one of the main bronchi by passing it through the larynx during bronchoscopy or by indirect laryngoscopy. Some efforts have been undertaken to atomize the contrast medium and thus permit it to be inhaled directly without anesthesia or instrumentation. Hickey attempted to effectuate such a method in 1924 but was unsuccessful. An effective method of simpler instillation would doubtless be of great advantage.

Regardless of the method of introduction, the value of bronchography in the chronic diseases of the lung cannot be overestimated (164). It permits a visual mapping out of the bronchial tree of each lobe and the determination of the condition of the bronchi at each point. Bronchography extends the physician's view far beyond the end of the bronchoscope; it permits diagnosis at points well beyond the bell of the stethoscope. The fact is that it accounts in considerable part for the relative infrequency of exploratory operations on the chest. In the diagnosis of tumors and inflammations of the bronchi it is of the first importance. One of the real contributions which has aided materially in permitting the great forward strides of thoracic surgery is this method of visual exploration of the lungs with the thorax intact.

The next step in the unfolding picture of the development of contrast media was epoch-making in that it presented an entirely new method of approach. In 1923, Graham and Cole (81) conceived the brilliant idea of substituting a heavier halogen

for the chlorine in sodium tetrachlorphenolphthalein, a drug which had been found by Abel and Rowntree (1) to be excreted by the liver. Sodium tetrabromphenolphthalein and tetraiodophenolphthalein were made, and it was soon found that the intravenous injection of these substances would give a distinct dense shadow of the normal gallbladder. For the first time, a contrast medium was introduced into an organ as a result of its physiology, and the x-ray examination became a test of function as well as a demonstration of gross anatomy and pathology. This exposition of the possibility of utilizing organ function for the introduction of contrast media opened an entirely new field of endeavor which has not yet been fully explored, while at the same time it served to establish the roentgengraphic examination of the gallbladder on a sound basis. Further experimentation followed, notably by Graham, Cole, Copher and Moore (82, 83), Menees and Robinson (142), Milliken and Whitaker (145), and many others, until the iodinated form was well established as the drug of choice. The oral method was instituted and made successful by the use of various vehicles, and the fatty meal was initiated by Boyden (21) as a test of gallbladder emptying. A host of studies of the normal and pathological gallbladder, of its physiology, of its relationship to the sphincter of Oddi have been the consequence of this original work. Of even greater importance, however, was the stimulus given to further studies in other organs, using similar principles of approach.

In 1940 a newer drug, beta(3,5 di-iodo-4-hydroxyphenyl) alpha phenyl propionic acid, was produced, under the trade name Biliselectan (127) for the roentgen examination of the gallbladder. This has come into wide use in this country under the name of Priodax (65, 90), exhibiting certain advantages over such phenolphthalein compounds as Iodeikon. The newer drug does not produce diarrhea nor toxic manifestations of any degree and it appears to produce a denser gallbladder shadow with more constant absorption on oral administration. It is still not fully tested, and certain difficulties may arise, but it appears to be a very satisfactory medium for this purpose.

In 1923, Rowntree and his co-workers (180) conceived the idea that the urinary tract might be made roentgen-opaque by utilizing its function of excretion. They accordingly made roentgen studies of the kidney and bladder after the intravenous injection of very large quantities of a saturated sodium iodide solution. While the experiment was not highly successful, because of the large amount of a toxic drug which had to be given, it nevertheless pointed the way to a new type of x-ray examination of the urinary tract. Finally, in 1928, Lichtwitz, Swick (202), and von Lichtenberg (131), with the aid of a number of organic chemists, produced an organic iodine compound, the sodium salt of 5-iodo-2-pyridon-N-acetic acid, which was excreted almost wholly by the kidneys and produced sufficient x-ray density to give a clear delineation of the renal pelves, ureters, and bladder. Further experiments resulted in the production of a large number of similar compounds, some having somewhat different properties, but all effective as excretory contrast media. Swick (203) later introduced sodium ortho-iodo-hippurate (Hippuran), which could be given orally or even intramuscularly with some success. Thus a new era in urologic diagnosis was achieved. Without cystoscopy and its attendant difficulties, with little or no risk, adequate roentgen visualization of the urinary tract could be obtained, while at the same time a test of the individual function of each kidney was accomplished.

Excretion urography is the method of choice for the routine examination of the urinary tract, particularly if glomerular function is not seriously disturbed; it is commonly used as a preliminary procedure before cystoscopy or retrograde pyelography is initiated. Furthermore, the same iodine compounds, such as Diodrast and Neo-Iopax, were found highly

useful in other fields, notably angiography, contrast cardiography, and cholangiography. Some of them, such as Skiodan, the mono-iodo-methane sulfonate of sodium, are being used for retrograde pyelography as well.

The liver, spleen, and pancreas remained relatively untouched during the introduction of methods to enhance the x-ray density of internal organs. It is true that Einhorn and Stewart (64) attempted to make x-ray examination of the liver after the intravenous injection of Iodeikon, but as the concentration of the iodine was insufficient within the limits imposed by the toxicity of the drug, their efforts were unsuccessful. In 1928, Oka (156) and Radt (170) began experiments with colloidal emulsions to obtain roentgen visualization of the liver and spleen; they proposed to take advantage of the function of the reticulo-endothelial cells of these two organs, that of ingestion of particulate matter found in the blood. Kadrnka (111) helped to produce a relatively stable colloid with small enough particles so that thromboses or capillary obstruction would not be produced. The material used was a colloidal suspension of thorium dioxide called Thorotrast. The intravenous injection of quantities approximating 0.8 gm. per kilogram of body weight resulted in the production of a fairly dense shadow of both liver and spleen. A fairly exact demonstration of the size, shape, and position of these organs and considerable information as to their internal structure were thus obtained. Destructive lesions, such as tumors which replaced the reticulo-endothelial tissue, would leave defects in the roentgenographic shadow. The diagnosis of metastases, primary tumors, cirrhosis, abscess, and other liver diseases could be determined with a reasonable degree of accuracy.

Unfortunately there are two disadvantages in the use of Thorotrast. Thorium dioxide is radioactive and might, therefore, have deleterious effects. Furthermore, the material remains in the liver and spleen and regional lymph nodes for many years, disappearing very gradually, so that a foreign-body effect is produced, in addition to the effects of the alpha radiation. Extensive studies on animals and on man have been made with equivocal results. If large enough doses are used, most certainly very injurious effects will result. With moderate doses, there is grave doubt that any harm will eventuate. Follow-up studies by Yater, Otell, and Hussey (223) and by Rigler, Koucky, and Abraham (175) did not show any serious after-effects, but the author has observed distinct fibrosis of the spleen with marked diminution in size over a ten-year period. There also occurs some fibrosis of the liver, although without appreciable effect on liver function; distinct fibrosis and necrosis of lymph nodes may likewise be found. Regardless of such findings, it seems inadvisable, except under special conditions, to introduce into the liver and spleen, for diagnostic puposes, a medium which will not be eliminated. There is also the possibility that the material may have a local carcinogenic effect. As a result, the procedure is used very little, although diseases of the liver still remain one of the most difficult problems of diagnosis in the field of internal medicine. The same contrast medium has been used effectively in other examinations, as in angiography, cholangiography, uterosalpingography, ventriculography, myelography, and others. Where it is reasonably certain that it will be eliminated, as in cholangiography, there can be little objection to its use. In the case of angiography, the amount injected is ordinarily sufficiently small to make it reasonably safe.

The reluctance to use thorium dioxide sol for the x-ray examination of the liver has led to further researches in this field. The author and his associates attempted to produce a colloidal suspension of an iodized oil as a substitute for the thorium suspension, but were never able to get sufficient concentration of iodine into the liver of an animal without using enormous quantities of the emulsion, far beyond the danger point. In 1937 Degkwitz (60) pro-

duced a colloidal emulsion, ethyl tri-iodo stearate (Iodosol) which Beckermann and Popken (16) applied to the visualization of the liver and spleen. The principle of application was the same as that for thorium dioxide; namely, the introduction into the blood stream of particulate matter which would be ingested by the reticulo-endothelial cells of the liver and spleen. It differs in that Iodosol breaks down within a few hours and is excreted in the form of sodium and potassium iodide. A recent paper by Olsson (157) gives the present data clearly; unfortunately he also reports some severe reactions, with one death in nine cases. Twenty grams of iodine must be given; this alone is not without serious danger, as it will be absorbed within a period of hours. Furthermore, the colloid is evidently not entirely stable and produces reactions of itself. The problem, of visualization of the liver and spleen is, therefore, far from being solved, although efforts in the direction of Degkwitz' fundamental work on the distribution of colloids may make it possible. This is one of the remaining unsolved problems in roentgen diagnosis.

As shown in the accompanying figures (pages 470 and 472), in almost all of the anatomical structures to be examined there has been a gradual evolution of method and material. The first efforts to examine the central nervous system effectively with the roentgen rays date from Dandy's (58) historical description of the use of air introduced directly into the cerebral ventricles. Later he described the intraspinal injection of air (59), but myelography as such was not well instituted until 1922, when Sicard and Forestier (193) reported apparently innocuous effects from the instillation of Lipiodol into the spinal canal. Used originally for the diagnosis of tumors, its usefulness has been greatly extended since the work of Mixter and Barr (148) and Hampton and Robinson (88) on the x-ray diagnosis of herniation of the intervertebral disk. Some serious doubts having arisen as to the complete harmlessness of iodized oil in the spinal canal and ventricles of the brain, efforts at providing a substitute which would be absorbed or could be removed more rapidly have continued. Air as a medium of contrast was substituted (50, 225, 46) but was never universally adopted because of the difficulty of interpretation of air spinograms. Thorotrast was advocated also (154), but the persistence of the material in the canal and the possibility that it was locally carcinogenic in its effect led to its abandonment. Extensive experimentation by a team of chemists and radiologists extending over a period of years led eventually to a new contrast medium which will, no doubt, replace iodized oil for this purpose. Strain, Plati, and Warren (200) first reported their work with ethyl iodophenylundecylate (Pantopaque) in 1942 and it has since been given extensive clinical trial. The procedure of removing the contrast medium, either iodized oil or Pantopaque, from the spinal canal (125) has added immeasurably to the field of usefulness of myelography.

A method for the roentgen examination of the peripheral nerves was first proposed by Löhr and Jacobi (134) in 1932. They injected thorium dioxide sol along the nerve sheaths and thereby were able to demonstrate the effects of injury, tumors, and other pathological processes. The method has not been widely adopted, although Saito (183) has used it rather extensively.

The x-ray demonstration of the blood vessels by means of contrast media, administered in one form or another, was first projected in 1896, when mercury was injected into cadavers. The same procedure may be used effectively today for the delineation of the arterial system in an amputated extremity. Hickey (95) used a bismuth glycerine mixture in cadavers to study the anatomy of the circulation. The first clinical attempt was made in 1923 with strontium bromide, following which numerous substances were utilized. Dos Santos and Pereira Caldas (186) introduced the use of thorium dioxide sol for demonstration of the arteries in 1931 and

this medium was later employed for venography as well. The various organic iodine preparations are frequently used for this purpose and more recently Iodosol has been utilized by Häussler, Döring, and Hämmerli (87). In selected cases, the roentgen studies of the veins to which Baker and Miller (10) and others (13, 222) have given so much effort are exceedingly valuable, while arteriography is also helpful in the diagnosis of diseases of the extremities (160, 5, 211).

In 1927 Egas Moniz (61) first made a successful demonstration of the cerebral arteries, using sodium bromide; later he achieved the same result with sodium iodide. By injection of the medium into the internal carotid artery he was able to demonstrate deformities and displacements of the vessels incident to tumors and other lesions of the brain. Later he adopted thorium dioxide sol as a medium, while others have used organic iodine compounds, especially Perabrodil. Kristiansen and Cammermeyer (124) and, more recently, List, Burge, and Hodges (133) have delineated the value of arterio-encephalography or cerebral angiography.

While many studies have been made on cadavers and experimental animals to determine the anatomy of the pulmonary vessels and to relate them to the shadows observed in the ordinary roentgenogram, it was not until 1931 that any success was achieved in making such a demonstration in the living human being (62). This was effected by passing an opaque catheter into the median basilic vein under fluoroscopic control. The catheter was then passed into the superior vena cava and even into the right atrium, whereupon a highly concentrated sodium iodide solution was injected; roentgenograms made immediately gave excellent shadows of the pulmonary arteries. While some modifications of this procedure are still being used in experimental work, particularly for measuring the pressure in the right atrium and even in the right ventricle, it has not attained any considerable use as an x-ray diagnostic procedure, no doubt because of the attendant risk and the difficulty of approach.

A much safer and less trying procedure was described by Robb and Steinberg (176) in 1938. They injected a 70 per cent solution of Diodrast into the median basilic vein with great rapidity and made repeated rapid exposures of the heart and lungs. Preliminary measurements of the circulation time permitted a determination of the desirable intervals between the roentgenograms. This method has some practical diagnostic value but is of even greater importance as a means of studying the physiology of the heart and lungs. It offers some aid in the diagnosis of congenital heart lesions and pulmonary artery disease and in the differentiation of vascular masses from mediastinal tumors. A similar method was applied to children by Castellanos, Pereiras, and Argelio García (44), who called it angiocardiography. Much information as to the roentgen anatomy of the heart in health and disease can also be obtained in this fashion, as indicated by the papers of Sussman and his co-workers (196, 84), and in a recent contribution by Miller (144). It should be noted that earlier German investigators had utilized a combination of iodized oil and Thorotrast in animals, and even in one case in man, to demonstrate by fluoroscopic motion pictures the filling of the right atrium. Stewart and his associates (197) likewise made motion pictures of the fluoroscopic image of the living, pulsating heart when filled with contrast medium by the Robb and Steinberg method. The procedure has not yet been followed through to its full promise. It appears likely that an increase in the intensity of the fluorescent image, which will, no doubt, soon be accomplished, may permit much more to be learned from motion pictures of the opacified heart, because in such a manner the individual chambers may be adequately studied.

Using similar methods, in 1929, dos Santos and his co-workers (187) devised a means for the x-ray examination of the abdominal aorta. They plunged a needle

directly into the aorta through the lumbar muscles and injected concentrated sodium iodide solution and later thorium dioxide sol under great pressure. Not only could roentgenograms of the abdominal aorta be obtained in this way but the various branches, as the splenic, celiac, renal, and ovarian arteries, were also rendered radio-opaque. Fariñas and his colleagues (69) have further modified this technic by injecting Thorotrast through a catheter introduced into the abdominal aorta through an incision in the femoral artery. Changes in the arteries due to tumors or other diseases can thus be clearly demonstrated.

The usefulness of contrast media in the x-ray diagnosis of diseases of the female generative organs is rather more circumscribed, but here too the effort to produce contrast was begun rather early—in 1914—by Cary (40), using Collargol. Rubin (181) introduced his test for the patency of the fallopian tubes, using air, in 1920 and, about the same time, Heuser (92) produced roentgenograms of the cavity of the uterus and of the lumina of the tubes after injecting iodized oil directly into the cervical os through the vagina. Since then a variety of media have been used, but iodized oil is still the substance most commonly preferred.

A new method for the x-ray delineation of internal organs—cholangiography—was instituted in 1924, when iodized oil was injected into an external biliary fistula and a clear delineation of the major biliary ducts was produced (126). An earlier attempt, with an emulsion of barium, had been unsuccessful (39). Further studies led to Mirrizi's procedure (146, 147), in which the contrast medium was injected into the common bile duct by way of the gallbladder, or directly, while the abdomen was open during operation. By this means it became possible to determine the patency of the ductus choledochus and the presence of stones before closing the abdomen. If a permanent drain were left in the gallbladder or common duct, further observations of a similar kind could be made under more favorable conditions, at any time after operation. Such procedure is now widely used whenever it is suspected that calculi may be present in the common duct. Saralegui (188), using thorium suspensions, made splendid studies of the physiology of the duct. Mirrizi (147) advocates the use of iodine preparations, which in the author's hands have been far more satisfactory than iodized oil and safer than Thorotrast. Many others have contributed in this field (79, 93, 177).

Contrast examination of the joints has been used from time to time. Efforts at the visualization of the synovial membranes and cartilages began in 1905, when Hoffa (101) and others introduced air into joints for purposes of contrast and made x-ray studies. Burman, Tunick and Pomeranz (29) used iodized oil in 1932. Michaëlis (143) and many others utilized the various organic iodine compounds. Oberholzer (155) even used Thorotrast experimentally for this purpose. Finally Bircher (18) advocated the combined use of an iodine compound with oxygen, thus giving a double contrast. The procedure is not frequently used, but in certain cases may be of great value, as illustrated by the review written by Lindblom (132).

As was to be expected, certain procedures for the production of contrast in the x-ray examination of the soft tissues have been abandoned. One of these was amniography, first described by Menees, Miller, and Holly (141). The results of a direct injection of strontium bromide into the amniotic sac in pregnant women to permit visualization of the fetal soft parts and the placenta were often so deleterious that the method was never widely used. More recently Ehrhardt (63) used Iodosol intravenously in animals, finding that it was deposited in the placenta and could therefore identify abnormalities of that structure. The method has not yet been put to clinical trial.

A method of indirect visualization of the placenta by the use of contrast medium in the urinary bladder has been described by Ude and his co-workers (209). They injected air and later sodium iodide in small

quantities into the bladder and were able to recognize the presence or absence of the placenta in the lower uterine segment by the extent of the separation of the fetal head from the shadow of the bladder. A perfectly safe procedure, indirect placentography is reasonably accurate and of the first importance in the early diagnosis of placenta praevia.

Another procedure which has not been fully accepted is mammography. The injection of thorium dioxide sol into the breast (94) for the demonstration of the lacteal ducts, by which means distortion or obstruction by tumors or other diseases could be observed, has not been pursued further because of the inherent dangers. Air and carbon dioxide have also been used, and in one instance iodized oil, but the method has never met with any widespread approval.

Such a recital of accomplishments in the development of contrast media for roentgen diagnosis would scarcely be complete without noting the problems yet to be solved. First and foremost among these is a method for making the pancreas directly visible in the roentgenogram. It is true that in the past decade some progress has been made in the diagnosis of diseases of the pancreas through the medium of blood enzyme determinations and examination of the stools. Furthermore, the roentgen study of the displacements of neighboring organs, especially the stomach and colon, may occasionally be of considerable value; yet the pancreas still presents the physician with one of his most perplexing diagnostic pursuits. In occasional instances, in cholangiograms made after operation, the entire pancreatic duct, including even some of the smaller branches, can be clearly observed. In such cases one is afforded a glimpse into the possibilities of the roentgen examination of the pancreas which is stimulating, albeit not at all satisfying.

It is obvious from the discussion on previous pages that the present status of the diagnosis of diseases of the liver and spleen is far from satisfactory. Here, too, a more harmless but sufficiently radiopaque medium would be of profound value.

A method for enhancing the density of cartilaginous structures or increasing the contrast about them without the necessity of putting a needle into the joint would represent a striking advance. The manipulation by which a "vacuum" is induced in the joint cavity by stretching or twisting of the joint, as reported by Magnusson (138) and others, does produce some contrast, but it is scarcely a satisfactory method for the roentgen demonstration of the cartilages. The risk inherent in the needling of a joint has retarded the utilization of arthrography. It is conceivable that striking improvements in soft-tissue technic may permit visualization of the cartilaginous portion of the skeleton without the addition of a contrast medium.

In some situations the method of application of contrast media could be greatly improved. In ventriculography and encephalography, for example, the present approach, either through trephining the skull or by the intraspinal route, involves some danger and a great deal of distress. The synthesis of a contrast material which, upon intravenous injection, would be excreted through the choroid plexus, thereby enhancing the density of the spinal fluid, would solve many problems in the diagnosis of intracranial and intraspinal lesions. If we were able to apply x-ray examination as frequently to the central nervous system, when minor symptoms alone are present, as we do, for instance, to the urinary tract, there might appear a striking improvement in the therapeutic results.

Many other possible advances in the use of contrast media for x-ray diagnosis will suggest themselves and, no doubt, the years to come will substantiate the validity of some of these suggestions. The great strides that have been taken during the past half century can only indicate advances of a similar order in the future.

METHODS OF EXAMINATION

With its first breath of life, the roentgen method of examination divided itself into

two major procedures; for Röntgen discovered both the fluorescent effect of x-rays on a screen coated with crystals and the photographic effect on a sensitive emulsion almost simultaneously. Not long thereafter Pupin (168) devised a reasonably practical fluoroscopic screen, which much research has brought to the form of today—far superior, yet still imperfect. It is interesting to observe that as early as the second year of the utilization of x-rays for diagnosis there was conflict as to the respective merits of fluoroscopy and radiography. The great advantages of fluoroscopy in a wide variety of conditions, including especially the diagnosis of fractures, were extolled before a meeting of the London Roentgen Society in 1899 (149) while Brown (26) reports Wilbert's criticism of the practice in cases of injury.

Differences of opinion as to the relative position of the fluoroscopic procedure and radiography have persisted to a lesser degree up to the present time. We have passed through a period of controversy in this matter in the field of gastro-intestinal diagnosis which has been resolved in the minds of most radiologists by the sustained conclusion that each agency is supplemental to the other. Despite this, even in recent years, the author has heard one of the most respected elders in our group declare that it would be a great boon if all fluoroscopes were destroyed.

Fluoroscopy is now rarely used for the detection of fractures, although during the recent period of the war-induced shortage of x-ray film, many, no doubt, were tempted to resort to it again. But for study of the dynamic organs fluoroscopy remains invaluable. Holzknecht (104) and his colleagues in the Viennese School utilized fluoroscopy to its ultimate usefulness both in the examination of the heart, lungs, and diaphragm and in the study of the digestive tract. Carman (36) and his associates developed the art of fluoroscopy of the stomach and colon to a brilliant degree. Similarly, many another radiologist acquired a facility in roentgenoscopic observation which seemed to make radiographic studies almost unnecessary. The history of fluoroscopy, particularly as applied to the gastro-intestinal tract, has been splendidly related by Brown (28).

A modification of the ordinary fluoroscopic technic, originated by Moritz (151), called orthodiagraphy, makes it possible to obtain accurate measurements during the course of a roentgenoscopic examination. This technic has been applied principally to the study of the heart but can be used in other regions also.

The physical foundations of fluoroscopy, the advances in the procedure, and some possibilities for the future have been presented by Chamberlain (45).

Conversely, Cole and his associates (52) were convinced that multiple roentgenograms were far superior in value for interpretation of gastro-intestinal lesions; in addition, the method did not carry with it the inherent dangers of the fluoroscopic procedure. Forssell (73) and his followers, as well as many German radiologists, employed a fluoroscope which could be used as a positioning device for proper radiographic exposure while suitable, also, for real fluoroscopic study. Thus both purposes were adequately accomplished. The filming fluoroscope of Templeton and Hodges (204) is the modern equivalent.

Having passed through these various stages, the method of study at present giving most satisfaction to the largest number of radiologists is a judicious mixture of three procedures. Fluoroscopy is used in the study of the thoracic and abdominal organs and for the positioning of the patient for "spot" films; while radiography is used, in addition, for purposes of procuring detail, a permanent record, and the opportunity for unhurried study. In almost all other portions of the body, radiography alone is employed. It is true that fluoroscopy is applied, under special conditions, as an aid in the reduction of fractures, the location of foreign bodies, the observation of the position and passage of opaque tubes. In addition, it has been used to observe contractions of

the kidney pelves and ureters, for examination of the delivered kidney at the operating table to make certain as to the complete removal of stones, to assist in the procedure of myelography with iodized oil both during the introduction and removal of the substance, during bronchography, ventriculography, and in other such special procedures.

Radiography may be applied as a method anywhere in the body. The technics of its employment have undergone changes during the past fifty years which are the results of the development of new equipment and new methods of approach. Thus the introduction of the intensifying screen made a sharp improvement in the application of radiographic examination. Later the invention of the hot-cathode tube and still later of the rotating anode tube permitted even further advances in the art of radiography. The production of the double-coated film resulted in another striking improvement. No doubt Bucky's description of the principle of the moving diaphragm and Potter's application of it to a practical model made the greatest impact upon radiography.

Early in the history of roentgenology, Köhler (122) devised the method of teleoroentgenography especially for cardiac measurements. The procedure of making films with the tube at a great distance has now been adopted for many other purposes. Nevertheless, in fundamentals, the general methods of radiography remain the same.

That the principles of stereoscopy could be applied to radiographic procedures was conceived of by Elihu Thomson in 1896 (206) and Mackenzie-Davidson (137) utilized it as a method for localizing foreign bodies shortly thereafter, at the same time devising a method for viewing stereoscopic roentgenograms. From that time until the present day the stereoscopic process has been modified repeatedly, applied widely, given undue emphasis at times, unwisely deprecated at others. It need not be used routinely but is of great value in certain areas and under particular circumstances.

With the institution of methods of localization of foreign bodies by stereoscopy, by triangulation, and innumerable other modifications, have come systems of mensuration of various structures. Such measuring devices have been applied particularly to the determination of the exact size of the various diameters of the female pelvis which are important from an obstetrical point of view. Thus have been projected numerous procedures varying in complexity, some dependent on stereoscopy (99, 110, 31) and others on distortion corrections by the use of known factors (205, 11). The subject has been reviewed by Snow (194) and others.

The introduction of roentgenkymography by Stumpf (201) and a number of other investigators made a first departure from orthodox radiographic procedure for here either the film, or a heavy diaphragm before it, is in motion during the exposure, so that it becomes possible to record the movements of an organ on one film. The first efforts of Crane (56) in this direction were most prophetic. In this connection Jarre's (109) description of MacIntyre's effort to produce x-ray cinematographic film in 1897 is worth reading. The bold and imaginative investigations of that early day make us humble. But roentgenkymography is of a different character in that it can be performed on any patient, with little risk and with relatively little effort. Although its practical application is limited, it may nevertheless be extremely useful, particularly in the diagnosis of certain cardiac lesions, in the differentiation of mediastinal masses, and in the elucidation of abnormalities of motion anywhere. It has proved of particular value in the diagnosis of constrictive pericarditis, myocardial infarction, and calcification of the valves of the heart. Furthermore, studies with the roentgenkymograph have effectuated a distinct increase in our knowledge of the physiology of the heart. One of the striking utilizations of the instrument has been in experimental studies wherein it is desirable to measure the output of the heart

(114). The work of Hirsch (98) and of Scott and Moore (191) and others in this country, on roentgenkymography, especially of the heart, gave impetus to the method.

Another sharp departure from conventional radiography originated with Vallebona's (210) first description of a practical method of radiography of various body planes. This was preceded by the patent of Bocage (20). Ziedses des Plantes (226), Grossman (85), Kieffer (115), Moore (150), and Twining (208) have added materially to the perfection of this technic, which eventually should have a profound effect on roentgen diagnosis, particularly in certain organs. The review of Andrews (6) clarifies the methods and their value. Whether the procedure is designated as body-section roentgenography, tomography, planigraphy, stratigraphy, laminagraphy, the general principle is the same. It consists of a blurring out of certain planes of the body by keeping the x-ray film and the x-ray tube in motion throughout the exposure but maintaining such a relationship between the two as to preserve the sharpness of detail in the plane desired. The impact of this radical change from the usual type of radiography has been less than deserved, probably owing to the expense and time involved. Further experience, particularly in diseases of the chest, in diseases of the cranial and intracranial structures, and in the larynx, will undoubtedly demonstrate that the method is of inestimable value, both for practical diagnosis and as a means of study.

A means of accomplishing the same purpose as is achieved by body-section roentgenography was originally described by Cottenot (55). The method is called serioscopy and consists of the production of two sets of stereoscopic films with the tube shifting in different directions. Superimposition of the films and the shifting of their positions with relation to each other permit the examination of any number of planes, which can be sharpened or blurred out by appropriate changes in the relative positions of the four films.

Finally a combination of photography and fluoroscopy represents an extremely important departure from the conventional types of roentgen examination. Photofluorography, which, in a sense, dates back to the historic experiments of MacIntyre in 1896 (109) and of Bleyer (19) also in 1896, was first projected for mass examination of large numbers of the population, with miniature films, by D'Abreu (57) in 1936. Introduced into this country by Potter (165), the procedure of making a photographic record of the fluoroscopic image on small-sized film has rapidly become the accepted method for detecting lesions of pulmonary tuberculosis among apparently normal individuals. It is unnecessary to expatiate further here upon the history and present application of photofluorography, since it has been so recently described in the monograph by Hilleboe and Morgan (97). It should be noted that it may have a profound effect upon the future of roentgen diagnosis. The increase in routine examinations of various parts throws a great burden of responsibility on the radiologist for the diagnosis of disease at an early stage. While photofluorography, with its advantages of simplicity, relatively low cost, and rapidity of application, is now being applied solely to the thorax, it may possibly be improved to the point where it will be applicable to the gastro-intestinal tract and other organs. Thus, lesions which are so small as to be symptomless will be observed far more frequently than under present conditions and a much greater responsibility will fall upon him who is called upon to interpret their significance.

That the methods of roentgen examination are not static is apparent from the brief recital above. When it is considered that there is a close relationship between the principles employed in roentgenologic study and the science of electronics, it becomes perfectly evident that even greater changes are in store for the future. Probably nothing is more certain about roentgenology than the certainty of profound changes.

EVOLUTION OF DIAGNOSTIC CRITERIA

If progress in the roentgen diagnosis of the various systems had been logical, it might have assumed a very distinctive pattern. The first reasonable step in the development of the roentgen examination of any organ would be the demonstration of the normal roentgen anatomy, followed by a consideration of the common anatomical variations. After this would come the descriptions of the roentgen appearance of the various pathological affections of the organ, their variations and aberrations. Finally there would appear the roentgen signs which would assist in the differential diagnosis of one abnormal state from another. By the very nature of medical experimentation and study, however, no such consistent progression of ideas could be expected. For example, descriptions of the roentgen appearance of traumatic lesions of the bones and of bone tumors were reported some time preceding the detailed delineation of the roentgen picture of the normal skeletal structures.

Nevertheless, a kind of consistent thread can be detected running through the evolution of the roentgen diagnostic criteria of disease. The first steps are often hesitant and groping, as the pathology of a disease process is first recognized in the roentgenogram. The organ is then restudied to determine its normal appearance. Anatomical variations now enter the picture, leading to many false positive diagnoses. Such deviations are clarified and added to at irregular intervals, while definite criteria leading to the recognition of the roentgen signs of the disease are laid down. At about this time the brashness and overconfidence of youth assail the investigators so that the roentgen findings seem to be most specific and are considered to be pathognomonic of the disease. As time goes on and experience produces its usual salutary effect, the simulation of the roentgen appearance by other disease processes of different nature and etiology is revealed, so that the specificity of the signs is no longer valid. Finally, a more conservative point of view prevails and a reasonable interpretation of the significance of the roentgen findings is attained.

Essentially, roentgen diagnosis has consisted in the production of a special type of representation of the gross anatomical appearance of any organ, together with its aberrations under the influence of injury or disease. Added to this are the observations of certain changes in the normal functions of an organ, some of which, also, can be ascertained by means of roentgen examination. Early in the history of roentgen diagnosis, and, regrettably, too much so even today, the findings were looked at in the light of a photographic image, impressed upon the memory. When such an image was again encountered, it was recognized as the picture of a certain organ or a certain disease process. Soon, however, the enormous variations which biological processes always exhibit made it evident that no such simple feat of photographic memory was sufficient; consequently, specific details and characteristic criteria were recorded, classified, and then made into a composite picture. Even such a picture was not always complete; in many instances parts of the tableau were either distorted or missing altogether; but a sufficient number of the elements of the puzzle could be recognized frequently enough to make the identification of the process secure.

From this type of thinking, similar, no doubt, to that which permeates medical diagnosis in general, arose the conception of a typical roentgen picture of a disease process. Unfortunately, however, the term "typical" has too often been interpreted as meaning common. Nothing could be further from the truth, for if by a "typical" picture we mean the presence of all the criteria in characteristic form, it is infrequently encountered. But if we think of "typical" as inclusive of all the details and at the same time bear in mind that most of the cases will exhibit variations and fail to display many of the signs, the conception is most helpful.

In the course of events, many so-called

"characteristic" signs have been found to be fallacious while other findings of greater validity have been observed. From time to time, fresh observations are made upon old disease processes and new roentgen signs are recorded. Likewise, at intervals, new diseases are encountered. As such previously unrecognized pathological entities are uncovered, either at autopsy, by clinical examination, or as a result of roentgen studies, the x-ray findings have been tabulated, assessed, and reassessed until the new entity takes its place among the rapidly growing number of diseases which are recognizable by x-ray examination.

The progression of the events described above is less spectacular than those related in connection with the discovery of contrast media. Progress in the establishment of the roentgen criteria of disease is more plodding, with a great deal of detail in its fabric; accomplishment is, nevertheless, fully as great. In a masterful study, Percy Brown (26) reviewed in considerable detail the development of radiologic diagnosis through the first thirty-seven years of the roentgen era. It would be presumptuous to repeat his splendid analysis. There have been other detailed reviews of more restricted character (174). The *Year Books of Radiology* were begun in the very year that Brown completed his contribution and they furnish a complete survey of the progress in roentgen diagnosis from 1932 onward.

Certain outstanding events, however, in relation to the development of the roentgen diagnosis of a few of the systems may well be described, particularly as illustrations of the pattern of progress outlined above. It should be noted that any such description must necessarily be incomplete and may well do injustice to many investigators. Any such injustice will be entirely fortuitous.

It is not surprising that the first attention to the radiology of the bones and joints related itself almost entirely to traumatic conditions, but experience in this field led to further investigation of other bone lesions. Tumors and certain dyscrasias were readily observed, even in 1896, but a number of years elapsed before the radiographic technic and the knowledge of interpretation permitted any detailed consideration of bone tumors and infections.

By 1901, many traumatic lesions had been examined and Köhler (120) made the first of his many important contributions to roentgen diagnosis, a monograph on diseases of bone. The descriptions of disease processes in the skeleton proceeded apace, naturally arising in connection with clinical and pathologic reports. Hickey's work (96) on the development of the skeleton was of great importance at this time because it pointed to the necessity for familiarity with the normal. Earlier than that, Caldwell (169), Willard (220), Morton (152), Kassabian (112), Monell (149), and others in this country all made extensive descriptions of the roentgen appearance of pathologic processes in the skeleton.

Perhaps the most important publication was Köhler's book (121) on the borderline between the normal and the pathological in the roentgenogram, first appearing in 1910. The phenomenon of a radiologist with a modest office in the relatively small city of Wiesbaden producing so important a monograph may seem surprising. It was the result of painstaking study of the literature and careful observation which so inspired the interest and generosity of his colleagues that he was able to make a magnificent collection of cases with anatomical variations. Köhler's book has passed through many editions, was finally translated into English by Turnbull, and is now rather outdated, but it had an extremely important effect upon roentgen diagnosis, especially of the skeletal system. Anatomy had to be restudied to account for the numerous shadows which were observed in the roentgenogram. Numerous errors were made in the interpretation of such shadows until their innocent nature was established.

The descriptions of the roentgen findings in bone infections and bone tumors proceeded by way of case reports and classifications. The appearance of Kienböck's

(116) descriptions of bone infections and bone tumors and later the publication of Baetjer and Waters' monograph (9) were notable events. The latter authors particularly clarified the field in that they laid down specific criteria for the inspection of roentgenograms of the bones and then attempted to indicate which of these specific findings applied to various diseases. It would be fruitless to attempt to indicate further the progress in such an extensive field. Codman's (48) classical observations and classification of bone tumors is an excellent example of the use to which roentgen diagnosis can be put when interpreted in terms of pathology. Likewise Bloodgood's descriptions of tumors (77) indicated the relationship of their pathology to the roentgen manifestations. Important also was the monograph on bone tumors by Geschickter and Copeland (77), Brailsford's (24) book on the roentgenology of bones and joints, and a similar contribution by Hodges and others (100).

As a specific example of another type of progression, the case of hyperparathyroidism comes to mind. Descriptions of osteitis fibrosa cystica had been made even before the period of roentgen diagnosis. Adequate delineation of the roentgen findings was also recorded, but the etiology of the disease was obscure and therefore the x-ray observations of cysts on the one hand and decalcification on the other were not correlated. Mandl's description (139) of the real nature of the disease in 1926 led rather gradually to a reassessment of these roentgen findings. Hunter and Turnbull's paper (106), followed by those of Ballin (12), Camp (32), and later of Albright (3, 4) and his associates, as well as numerous others, served to classify and clarify the roentgen observations and to correlate them with the blood chemistry. As a result, we now have a reasonably good understanding of the pathogenesis of the disease and, at the same time, are in a much better position to recognize its manifestations in the roentgenogram.

A somewhat different situation pertains in the group of conditions characterized by aseptic necrosis of the epiphyses or the centers of ossification, often called osteochondritis. First described in the hip by a number of investigators as a result of both clinical and roentgen findings, it is at present largely dependent for its diagnosis upon x-ray examination. Furthermore stemming from the roentgen findings alone numerous other lesions of similar nature have been discovered. These include such entities as Köhler's disease of the navicula of the foot, Freiberg-Köhler's infraction of the head of the second metatarsal, Osgood Schlatter's disease of the tibial tuberosity Kienböck's disease of the os lunate Scheuermann's disease of the vertebra epiphyses, and many others. The etiolog and pathogenesis are not yet clearly unde stood, but the details of the gross patholog are known; they are so well delineated i the roentgenogram that it is possible t make the diagnosis almost unequivocal from the roentgen findings alone.

The roentgen examination of the ne represents an achievement largely of t past two decades. It is true that at a early period the shadows of the thym and of the enlarged thyroid were observe Examination of the pharynx, larynx, a trachea were difficult and unsatisfactor The publication of Hay's book (89) on t subject opened wide a field of endeav This was brought to greater fruition by t studies at the University of Pennsylvan and at Temple University. The additi of sectional radiography made the stu of the larynx a practical and highly i formative procedure, as pointed out so w by Young (224) and others. The volun by Pancoast, Pendergrass, and Schaef (158) covers the field in great detail a with admirable clarity. The roentg examination of the structures of the ne is now a well established procedure.

The history of the roentgen diagnosis disease of the gallbladder presents a stri ing illustration of the difficulties and eve tual accomplishments in the roentgen e amination of the internal viscera, yet it sufficiently circumscribed so that it may l reviewed within a limited space. Th

progress of events fits well into the general plan of the development of roentgen diagnosis. It is notable that the first observations were experimental in nature, gallstones being studied, after their removal, by Chappuis and Chauvel (47) in 1896. Further experiments of similar nature (78) resulted in some differentiation of the type of biliary calculus which would be amenable to roentgen demonstration. There appears to be some doubt as to whether Beck (15) or Buxbaum (30) was the first to demonstrate a gallstone in a living subject. For practical purposes it was of little significance, as the number of cases in which the procedure was effective was very small; but as a portent for the future, this first clinical experience was of great importance. By 1906, Holland (102) had pointed out some improvements in technic and there appeared to be more hope that x-ray examination would prove to be of substantial value.

A new method of diagnosis was introduced about 1910 by the contributions of Schürmayer (190) and of Pfahler (162), who observed secondary changes in the gastro-intestinal tract. The validity of such observations may well be challenged in the light of our present knowledge, but they represented a trend in observation which lasted for many years. Observations on the errors in interpretation of the various dense shadows found in the right upper quadrant by Holland (103) and Cole (51) led to differential diagnostic procedures to separate gallstones from kidney stones. Improvements in technic at this time led Case (41) to the conclusion, later concurred in by Pfahler (163), that 40 to 50 per cent of gallstones could be demonstrated by roentgen examination. We may now conclude that this was a highly optimistic statement. Even more optimistic were the later papers of Cole and George (53) and of George and Leonard (76), who emphasized the importance of an exacting technic. The monograph which the latter authors published in 1922 detailed both the diagnosis of calcium-containing stones and those which could be observed because of the fact that their density was less than that of the surrounding bile. They also used the secondary effects upon the stomach, duodenum, and colon as evidence of cholecystic disease. Furthermore, they put forth the thesis that the abnormal gallbladder might give a distinct shadow in the roentgenogram, though the normal viscus was invisible. Observations since the advent of cholecystography have indicated the fallacy of some of their data, but their contributions to increased accuracy of diagnosis by a meticulous technic were of the first importance. Their results, apparently proved at operation, were undoubtedly distorted by the well known frequency of cholecystic disease and of gallstones. Several years later Carman, MacCarty, and Camp (38) gave an illuminating discussion of such factors.

In 1924 cholecystography was introduced by Graham and his associates (81); the early history of the procedure has already been reviewed to some degree. Within a few years a new method of approach, which permitted a direct study of the gallbladder and its function, was established. There was discussion as to whether the oral method, introduced by Menees and Robinson (142) and later employed by Whitaker, Milliken, and Vogt (218) should be used or the intravenous route as advocated by Graham and Moore (83), Case (43), Carman (37), Waters (213), and others. The administration of a fatty meal, first introduced by Boyden (21) and later developed by Whitaker and Milliken (217) and by Sosman (195) became an important adjunct in the procedure. It was not long before optimistic statistics were collected to indicate how accurately gallbladder disease as well as gallstones could be diagnosed. Stewart (198) suggested the jejunal introduction of the dye and Sandström (184) devised a method for giving larger doses by dividing it into two portions. Choleretics were administered by Geling (75) to hasten excretion, and Antonucci (7) advised the intravenous administration of glucose.

Changes in the method of preparing the

material in order to facilitate its absorption were brought about. Levyn and Aaron in 1927 (130) suggested the addition of a fruit juice for this purpose. At about the same time Fantus (67) prepared a colloidal suspension of Iodeikon, which seemed to be easier to take and was more constantly absorbed.

While the statistical studies of Case (42), Kirklin (117), and many others indicated a high degree of accuracy, nevertheless various methods to improve technic went forward. There was a percentage of error in the diagnosis of stones of small size. Åkerlund (2), Bernstein (17), and others suggested that roentgenograms be made in the upright position, which permitted a distinct improvement in the demonstration of these smaller calculi.

With the aid of cholecystography Boyden (23) and his associates have carried on extensive studies on the physiology of the gallbladder and of the bile ducts, particularly as relates to the emptying time. Kommerell (123) suggested a study of the common duct during the emptying phase, and Copleman and Sussman (54) more recently have attempted to correlate such findings with disturbances of the physiological balance of the biliary tract.

Benign tumors of the gallbladder were first diagnosed by means of cholecystography by Kirklin in 1932 (118). A number of similar reports have since been made, but the demonstration of a carcinoma of the gallbladder by this means is exceedingly rare.

The gallbladder, no less than any other organ, exhibits anatomical variations which may frequently be mistaken for pathological states. Deformities are not uncommon and are frequently mistaken for adhesions. Boyden (22) described a deformity of the fundus which has been called the "phrygian cap" and demonstrated its innocent character. Bilobed gallbladders, double gallbladders, and absence of the gallbladder have all been described.

In the past few years a new contrast medium for cholecystography, Priod has been introduced. The history of t material has already been discussed. may well replace sodium tetraiodopher phthalein as the medium of choice.

On the whole, the diagnosis of the gr abnormalities of the gallbladder is o perfectly sound basis. As in other pa of the body, however, there still rem many unresolved problems related to normal functional states of the biliary tr Such syndromes as biliary dyskin should be amenable to roentgen diagno The full possibilities of cholecystogra are, therefore, still not completely plored.

Obviously, only a small portion of field of roentgen diagnosis, as related to criteria of abnormality, has been touc upon in the recitals given above. It sho be noted that there has been no intent to review fully any subject nor to cover field. The material presented is desig rather to throw some light on the charac of the progress which has been achie during this past half century.

VALUE AND LIMITATIONS OF ROENTGE DIAGNOSIS

A significant anniversary, such as one we are celebrating this year, may b propitious time to desist a moment fr our intensive efforts to advance the usef ness of roentgen diagnosis, while we ass the value of what has already been complished. It would perhaps be wise attempt some estimation of the prese status of roentgen diagnosis, to determi the place the roentgen method holds in t examination of the various body systen and to evaluate the reliance to be plac upon the findings obtained. We shou attempt to appraise the limitations as w as the range of the x-ray procedure. simple way to indicate the scope of t method consists in a recital of the indic tions for its use. The following tabulatio by systems, gives a rough estimate of t general usefulness of roentgen diagnosis i the light of our present knowledge.

Anatomical Parts and Disease Processes to Which Roentgen Diagnosis is Particularly Applicable

1. The *osseous system* including all the bones and joints for:
   (a) Congenital defects, dystrophies, disorders of nutrition and metabolism.
   (b) Traumatic injuries of all types.
   (c) Infections and inflammations which affect the bones or joints, directly or indirectly.
   (d) Tumors either arising in the bones or affecting them secondarily.
2. The *head*, including both the cranium and intracranial structures for:
   (a) All the diseases included above under the osseous system.
   (b) Suspected infections or tumors of the paranasal sinuses.
   (c) Inflammations or tumors of the mastoid and internal ear.
   (d) Most of the abnormalities of the teeth and jaws.
   (e) Suspected foreign bodies, especially metallic, and tumors of the eye.
   (f) Intracranial disease, especially brain tumors, brain abscesses, congenital disorders, and the end-results of trauma.
3. The *neck*, including especially the pharynx, larynx, trachea, thyroid, and lymph nodes for:
   (a) Foreign bodies, chronic infections, abscesses, and tumors affecting the pharynx, larynx, or trachea.
   (b) Enlargements of the thyroid gland.
   (c) Calcifications of the lymph nodes.
4. The *respiratory tract*, including the trachea, bronchi, lungs, pleurae, and diaphragm for:
   (a) Chronic diseases of the upper respiratory tract.
   (b) All acute and chronic diseases of the lower respiratory tract.
   (c) All suspected lesions, acute and chronic, congenital or acquired, of the pleurae and diaphragm.
5. The *mediastinum*, including the thyroid gland and thymus for:
   (a) Acute and chronic inflammations.
   (b) Tumors of all types including the lymphogranulomata.
   (c) Enlargements, from whatever cause, of the thyroid, thymus, or lymph nodes.
6. The *cardiovascular system* for:
   (a) Those lesions which may cause enlargement or deformity of the heart or abnormality of pulsation.
   (b) Calcifications of the heart or its valves.
   (c) All diseases of the pericardium.
   (d) Congenital anomalies, arteriosclerosis, inflammations, and aneurysms of the great vessels.
   (e) Anomalies, traumatic lesions, partial or complete obliteration of the arteries, varicosities, and thromboses of veins.
7. The *digestive tract*, with the exception of the pharynx, but including the esophagus, stomach, small intestine, and colon for:
   (a) Anomalies and distortions.
   (b) Ulcers, chronic inflammatory conditions, and fistulae.
   (c) Tumors of all types.
   (d) Traumatic lesions.
8. The *biliary tract*, particularly the gallbladder, but also the remaining ducts under special conditions, for:
   (a) All diseases of the gallbladder except during the acute stages.
   (b) The biliary ducts at or after operation with external drainage.
9. The *liver and spleen*, but, since the method of examination is probably not entirely harmless, the indications are not clearly established.
10. The *urinary tract*, including the kidneys, ureters, bladder, and urethra for:
    (a) Congenital anomalies, traumatic conditions, calculi, tumors, chronic infections, and the end-results of infection and obstruction. The so-called medical diseases of the kidney are less frequently an indication for roentgen examination.
    (b) In the bladder, in addition, the determination of the degree of enlargement of the intravesical lobe of the prostate.
    (c) Determining the patency of the urethra.
11. The *abdomen in general* for:
    (a) Evidences of rupture, from trauma or disease, of any abdominal organ.
    (b) General peritonitis with or without abscess formation.
    (c) Acute surgical diseases such as acute appendicitis, acute intestinal obstruction, perinephric abscess, or subphrenic abscess.
    (d) Miscellaneous tumors and enlargements of the various organs.
    (e) Intraperitoneal adhesions.
12. The *female genital tract* for:
    (a) Accurate measurement of the bony pelvis.
    (b) Determination of the patency of the fallopian tubes.
    (c) Tumors and anomalies of the uterus.
    (d) The diagnosis of pregnancy and the determination of abnormalities of the fetus or its presentation.
13. The *soft tissues* anywhere in the body, including the breasts. The indications for examination of these structures are not yet fully established. In certain selected cases, notably in subcutaneous emphysema, from gas infection or trauma, in the diagnosis of lipomata, and in certain lesions of the breast, the findings are of great value.
14. *Miscellaneous conditions*, including lesions of the seminal vesicles, the salivary ducts, concrements, calcifications, and foreign bodies, particularly those of metallic origin.

This bare outline of the indications for roentgen examination gives some concept of the manner in which this method of diagnosis cuts across all the specialties and affects the management of many patients. Certain striking omissions from the list emphasize the limitations of the method. Diseases of the skin are not mentioned, and lesions of the breast are a doubtful indication. Many of the diseases of the eye, the nose, the mouth, the pharynx, and the larynx do not demand x-ray study. Likewise, little help will be obtained in the examination of the subcutaneous tissues and the muscles. There is only minor mention of the liver and spleen, while the pancreas, adrenals, ovaries, and salivary glands are scarcely considered, indicating the small part which roentgen examination plays in the diagnosis of diseases of these structures.

Tropical diseases, which have become so well recognized since the beginning of the war, are only moderately affected by roentgen studies. In yaws the changes in the bones can be demonstrated. In schistosomiasis, the enlarged spleen, cirrhotic liver, and esophageal varices can also be delineated by roentgen study. Likewise in filariasis, the liver and spleen changes are demonstrable, particularly if hepatosplenography is used. In the same way the vascular obstructions can be localized by the use of contrast media. In a few other situations the roentgen examination may be of some value but, on the whole, the usefulness of the procedure in this group of conditions is sharply restricted.

An even more searching question relates itself to the general value which may be attached to x-ray examination in any particular portion of the body. A few illustrations of this kind may suffice to indicate the present status. While roentgen examination is undoubtedly extremely accurate in the detection of fractures in all parts of the skeleton, and certainly is the most dependable way of obtaining such information, the results of x-ray examination of the joints, or of any of the cartilaginous structures, are far from accurate. In the ordinary course of traumatic injuries, many serious disabilities may arise because of damage to tendons, ligaments, and other soft parts, which may give little or no manifestations on x-ray examination. A negative report, therefore, in this respect is o[illegible] little significance.

Even more striking are the value an[illegible] limitations of x-ray examination in sus[illegible]pected skull fractures. In such instances great effort is often exerted to execut[illegible] an adequate roentgen study immediatel[illegible] after the injury. For practical purpose[illegible] such a procedure is of importance in onl[illegible] two respects: to produce evidence fo[illegible] medicolegal purposes and to rule out a de[illegible]pressed fracture necessitating immediat[illegible] surgery. Aside from the latter considera[illegible]tion, the roentgen examination adds littl[illegible] to the clinical findings in determining th[illegible] immediate conduct of the case. Th[illegible] treatment and prognosis are contingen[illegible] largely upon the extent of brain injur[illegible] and this has little compulsive relationshi[illegible] to the presence or extent of a skull frac[illegible]ture. A negative x-ray examination do[illegible] not rule out cerebral hemorrhage or cer[illegible]bral injury; a successful demonstratio[illegible] of a fracture does not necessarily indica[illegible] serious damage to the brain. Finally, [illegible] should be pointed out that even toda[illegible] with the best technical procedures, a larg[illegible] percentage of fractures of the base of th[illegible] skull cannot be demonstrated in the roent[illegible]genogram.

In inflammations of the extremiti[illegible] without bone involvement, it is clear tha[illegible] the clinical findings are far more importan[illegible] than those adduced by roentgen stud[illegible] Furthermore, in the early stages of an in[illegible]flammatory disease of the skeleton, wheth[illegible] it be acute osteomyelitis or acute arthriti[illegible] a negative examination is again of no sig[illegible]nificance. There are definite reasons fo[illegible] the failure of the roentgenogram to recor[illegible] bone infection in its earliest stages. It i[illegible] conceivable that improvements in techni[illegible] may vitiate some of these factors. Never[illegible]theless, at present it is important to appre[illegible]ciate such limitations of an otherwise usefu[illegible]

method. When seven to fourteen days have elapsed from the onset, in the subacute stage, the results of the roentgen study assume great importance. The exact location, extent, nature, and severity of an inflammatory lesion of the bone may then be ascertained; the information acquired is invaluable, but for early diagnosis of bone infection one cannot depend to any great extent upon the roentgen study.

In appraising the emphasis which should be placed upon the x-ray findings in lesions of the thoracic organs, a few outstanding examples may be cited. Certain diseases, such as acute bronchitis, milder cases of chronic bronchitis, and the early stages of bronchial asthma, may be present without any roentgen manifestations whatever. In contrast to these, lobar pneumonia may be detected within six hours after its onset—in a few cases even earlier—well before diagnostic physical signs are present. Such a disease as pneumoconiosis can scarcely be recognized in its early stages by any other means.

In the diagnosis of pulmonary tuberculosis, the significance of negative and positive findings is of grave importance. It is very unusual to find symptom-producing pulmonary tuberculosis, of the ordinary chronic type, without positive roentgen findings. In such cases, therefore, assuming an adequate, well executed, well interpreted roentgen examination, a negative picture is of great significance. There are, no doubt, some exceptions to this rule, but they are so infrequent that the dictum may be safely followed. In the case of the more acute types of pulmonary disease, such as acute miliary tuberculosis, the rule does not hold, for severe symptoms may be present for as long as six weeks before the findings become sufficiently characteristic to justify a definite diagnosis. A negative finding in such a situation is of little value. Furthermore, a negative roentgen study, does not exclude pulmonary tuberculosis when there are no symptoms. During the routine examination of the chest of apparently normal individuals it is easily possible for a focus of tuberculosis to be present but so undeveloped as to escape roentgen detection. A period of as long as twenty weeks may elapse after exposure to tuberculosis before the x-ray findings become unequivocally positive.

The significance of positive findings varies much more greatly, depending upon the nature of the findings themselves. Despite many errors in the roentgen diagnosis of pulmonary tuberculosis, the changes observable in the roentgenogram are second only to a positive sputum in the final diagnosis. The findings are almost invariably definite before any symptoms have appeared. In a great many cases, however, the changes which are visible are not specific; the roentgenologists must therefore limit themselves to the statement that abnormality is present but the etiology must be definitely determined by other means.

The relative value of roentgen examination is strikingly illustrated by a consideration of lung tumors. The presence or absence of pulmonary metastases can be determined with extraordinary accuracy by the roentgenographic study of the chest; usually they are evident long before there are any symptoms or physical signs. In many cases the shadows are so specific that little doubt need be entertained as to the nature of the lesion. In other instances, of infiltrative metastases and very small lesions, there may be some doubt as to the nature of the process present, although the findings themselves are perfectly apparent. Metastases to the lungs, of such a nature as to be almost perfectly characteristic, have been observed even though the individual lesion was no larger than 3 mm. in diameter.

The situation presented by the roentgen diagnosis of primary lung tumors is in sharp contrast to that of metastatic deposits. In a small percentage of cases the patient may have symptoms without any x-ray findings whatever. In the vast majority some roentgenologic findings will be obtained if a thorough roentgen study is made, but the nature of the process may not be apparent. A complete examination,

including fluoroscopy, roentgenography in several positions, bronchography, and possibly even body-section roentgenography, may give definite findings, but despite all possible procedures the changes may mimic most completely a variety of other conditions. Primary carcinoma of the lung simulates tuberculosis, pulmonary abscess, bronchiectasis, benign adenoma of the bronchus, and metastases. On the other hand, to make matters even more complex, atypical inflammatory lesions may closely resemble bronchiogenic carcinoma. Not infrequently a diagnosis of primary bronchiogenic carcinoma has been made in the presence of an atypical perihilar tuberculosis. It should be emphasized, nevertheless, that the roentgen study is of great value in the recognition of primary lung tumors. Frequently it is the only effective means of diagnosis. When the roentgen changes are assessed with all the findings, they add immeasurably to the possibilities of early diagnosis of this serious disease. Nevertheless, the accuracy of the method is far greater in the metastatic than the primary lung tumor.

Diseases of the heart also serve as an apt illustration of the differences in the value of roentgen examination in various diseases. Most, although not all, of the congenital defects, well established valvular lesions, and cases of moderately advanced hypertensive heart disease will manifest themselves in the roentgenogram by distinctive changes in the size and contour of the heart. It is not always possible to interpret these in terms of the exact nature of the cardiac disease, but findings of some type to indicate an abnormal heart will be obtained. To the contrary, such serious diseases as coronary sclerosis and coronary thrombosis, in a great many instances, fail to give any evidence whatever of their presence even with the most searching roentgen study. It is true that in some cases roentgenkymography may assist in determining the presence of a myocardial infarct, but the accuracy is still on a low level and little dependence can yet be placed upon this method of examination.

A few more examples in the field of abdominal diseases may further emphasiz[e] the importance of an appreciation of th[e] possibilities of roentgen examination There is unquestionably no more importan[t] procedure in the diagnosis of organi[c] disease of the gastro-intestinal tract tha[n] the x-ray examination. Particularly in th[e] recognition of the serious, death-dealin[g] lesions of the stomach, such as ulcer an[d] carcinoma, the barium-meal study is th[e] criterion for accurate diagnosis. But th[e] great majority of patients who complain o[f] gastric symptoms have neither of thes[e] lesions. A negative roentgen examinatio[n] of the stomach, therefore, providing it ha[s] been done competently, only justifies th[e] physician in telling the patient he has n[o] serious disease. The vast and relativel[y] unexplored realm of the gastric neurose[s,] the functional disorders of the stomac[h] and even the acute and chronic no[n-] ulcerous inflammations, is relatively litt[le] affected, diagnostically, by roentgen stud[y.] To a limited extent, the same is true of th[e] remainder of the digestive tract.

Diseases of the gallbladder and urina[ry] tract lend themselves to an even more a[c]curate estimate of the value of roentg[en] examination. It is reasonable to conclud[e,] for example, that at least 90 per cent of th[e] patients who exhibit a normally functio[n]ing gallbladder on cholecystography hav[e] no appreciable disease of that orga[n.] Possibly the percentage is even highe[r.] Furthermore, with cholecystography we[ll] done, the absence of a gallbladder shado[w] or the presence of stones is indicative of [a] pathological process in at least 95 per cen[t] of the cases.

In a patient suspected of having a kidne[y] stone, what is the significance of a neg[a]tive roentgen examination of the urinar[y] tract, providing intravenous urography ha[s] not been used? The answers to this ques[]tion will vary to some degree, but in a[ll] likelihood not more than 10 per cent o[f] upper urinary tract stones will fail to b[e] manifested by good roentgen studies. Probably, not more than 3 per cent o[f] upper urinary tract stones are non-opaqu[e]

to x-ray examination, but, owing to other errors which enter into the average type of roentgen study, 10 per cent is a fair figure. Here again negative findings do not exclude the presenee of a kidney stone, although they render it improbable. It is more important that a simple roentgenogram may fail to give any indieation whatever of a severe pyelitis, pyelonephritis, tuberculosis, tumor, or any of the glomerular or sclerotic lesions of the kidney. The addition of excretion urography or retrograde pyelography will obviously reduce appreciably the pereentage of error. The use of a contrast medium will permit the diagnosis of some of the lesions, sueh as pyelitis and pyelonephritis, tuberculosis and tumor, but moderate degrees of glomerulonephritis or arterioselerotie kidney may be present without any very appreciable effeet.

A similar analysis could be applied to the whole gamut of roentgen diagnostic procedures. One somewhat eonsistent rule runs through the whole story—a negative roentgen examination is much less significant than a positive one. This, however, is not always true, as in the case of pulmonary tuberculosis deseribed above; likewise, in osteogenic bone tumors negative findings are of great significance. On the positive side it should be noted that, in general, the roentgen examination is an excellent method for demonstrating the presence of an abnormality. Frequently, however, it is much more difficult, occasionally impossible, to determine accurately the nature or etiology of a lesion. Again there are many striking exceptions, particularly illustrated by the osteogenic bone tumors, mentioned above. Here the roentgen examination is not only the most accurate method of establishing the presence of a tumor but also in determining its nature. On the whole, however, in many cases, all of the clinical findings must be weighed with the roentgen diagnosis to arrive at a correct conclusion as to the exact character of the disease process affecting the patient.

By his immortal discovery Röntgen has afforded the medical profession an instrument of incalculable worth in the diagnosis of disease. To use it well, nothing is of more importance than the knowledge of its possibilities and limitations.

THE FUTURE OF ROENTGEN DIAGNOSIS

Nothing in the realm of writing is more hazardous nor requires greater temerity than the attempt to glimpse the future. Nevertheless, at this point in the history of roentgen diagnosis, a half century after the discovery which made it possible, no great harm will be done by casting some type of prophetic glance into the near future of this method of procedure.

So far as seems possible to determine at the present time, roentgen diagnosis will continue to expand in scope and function. The discovery of a biological test for caneer, for example, might appear, at first glanee, to vitiate some of the need for x-ray examination. As a matter of faet, nothing eould be farther from the truth. Even if a biological test should indicate the presence of neoplastic disease somewhere in the body, it would still be necessary to localize the tumor and to determine its extent and limitations in order that therapy might be applied. In the same way, it has been suggested that the development of chemotherapy to its fullest potentialities may cause a sharp limitation in the necessity for roentgen examination. There is a grain of truth in this contention, as witness the diminished number of roentgen examinations of the mastoids during the past few years. Likewise, when chemotherapy is developed to the point where it may act as a preventive of certain inflammatory diseases such as pneumonia, for example, the necessity for roentgen examination of the lungs may be diminished to a degree. On the other hand, the ability to treat a disease effectively renders more imperative its early diagnosis. For this reason every means within our power must be exerted to make the diagnosis promptly and effectively, so that the therapy may be applied before serious damage occurs. The best illustration of this can be afforded

by the advances in thoracic and gastric surgery. Twenty years ago the average physician was so pessimistic about the outlook in cases of gastric or pulmonary carcinoma that he put forth no particularly strenuous effort to make the diagnosis certain; x-ray examination was often neglected in such instances, simply because of the feeling that it would do no good. At the present time the converse is true. The ability to cure malignant tumors of the lungs or stomach, if discovered at an early stage, has led to an intensive search for patients who have symptomless lesions. Thus routine fluoroscopic and radiographic examination of the chest is practised in the hope that small, symptomless carcinomas of the lung will be uncovered. Selected groups of patients, such as those with pernicious anemia or with achlorhydria, are subjected to routine roentgen examination of the stomach to discover small symptomless carcinomas which might be amenable to surgery.

Another factor in the usefulness of roentgen examination which may well affect the practice of roentgenology in the future is the increasing age of the population. The diseases which affect older persons are notably of such a character as to require roentgen examination. The increased incidence of tumors, which will undoubtedly occur as the population ages, will mean a sharp rise in the number of x-ray examinations which must be made per capita. The same is true of the increased incidence of chronic pulmonary disorders, chronic cardiac disorders, chronic arthritis, etc.—all of the diseases which comprise that vast accumulation called geriatrics.

Searching for light in dark places, the physician has been led by his ingenuity and inventiveness toward more and more visual instruments. Just as the x-ray examination is attractive because of the indirect visual picture it gives of the gross pathology of any organ, so the direct inspection of a structure is even more informative. During the past few decades, therefore, there have been amassed an amazing number of "scopes" of various kinds and description. All of these are, in a narrow sense, competitors of the roentgen method. In a larger sense, they supplement or complement the roentgen examination. Up to this time, at least, the institution of a direct visual approach to any structure has not resulted in any diminution of the necessity for roentgen study of that structure. On the contrary, in some instances, as in the case of the larynx, the roentgen method of examination has grown in usefulness concomitantly with the development of direct inspection. Where roentgen examination is at best difficult the development of an accurate visual method may tend to diminish its importance. In the lower segment of the rectum for example, where x-ray studies are usually unsatisfactory, adequate proctoscopy is no doubt superior in value.

A review of such procedures and their relationship to roentgen study may be of some interest. The development of adequate roentgen studies of the neck, particularly since the advent of body-section roentgenography, now offers useful additional information to the laryngologist, despite the most expert and careful direct laryngoscopy. The extent and distribution of a tumor, its infiltration outside the larynx proper, the involvement of neighboring structures, and other information of a like character can be furnished by x-ray examination although not obtainable with the laryngoscope (224).

In the case of the bronchial tree the problem is somewhat similar. What bronchoscopist would wish to do bronchoscopy without first having an adequate roentgen examination of the chest? In addition, in a great many instances, bronchography with iodized oil supplies information unobtainable in any other way.

The esophagus is even more amenable to roentgen study, as this can be so simply executed that diagnostic esophagoscopy is limited largely to obtaining biopsy material for final confirmation of the diagnosis or to investigation of the obscure case.

In recent years gastroscopy has likewise come to have considerable popularity.

Here, as is also the case with regard to bronchoscopy and esophagoscopy, the procedure is far more difficult and trying for the patient than x-ray examination. Furthermore, it is not nearly so universally available. On the whole, too, direct vision within the stomach is very circumscribed. In many situations, particularly for the diagnosis of gastritis, determination of the cause of hemorrhage from the stomach, and the detection of small tumors, the gastroscope is invaluable and may well be necessary in addition to x-ray examination. On the whole, however, gastroscopy is only a valuable supplementary procedure to the roentgen study. It should be undertaken whenever possible, and the findings obtained correlated with the x-ray findings, but gastroscopy should in no wise be thought of as a substitute for roentgen examination.

Examination of the thoracic cavity with the thoracoscope is largely a therapeutic procedure, and its applicability is so uncommon that it has no appreciable effect upon roentgen studies. In the case of the peritoneal cavity, however, the endoscopic examination is attaining considerable importance as a diagnostic procedure. Still not widely used, it may, in fact, increase the necessity for roentgen examination, if the procedure of Horan (105) becomes generally useful. He introduces a needle into the gallbladder under the guidance of the peritoneoscope and then injects a contrast medium so that cholangiography may be done without the ordinary surgical approach and without having a drainage tube in the biliary tract. By means of peritoneoscopy, it is possible to observe changes on the surface of the liver, such as metastases, cirrhosis, and other lesions; biopsy of the liver is also feasible. The development of biopsy methods reduces somewhat the importance of x-ray examination.

Both cystoscopy and urethroscopy occasionally make x-ray examination of the respective organs unnecessary, but again the over-all view obtained by cystography or urethrography is indispensable, so that roentgen studies are highly desirable.

As stated above, proctoscopy, and in many instances sigmoidoscopy, may furnish information as to the mucosa of the lower bowel which is superior to that obtainable by roentgen examination. The segment of the bowel which it is possible to inspect by this means, however, is small, so that x-ray studies must always be undertaken as well.

Generally speaking, the pursuit of an exact diagnosis is difficult enough in most situations so that every means at our command should be employed to its fullest extent. In the realm of the healing arts there should be no rivalry between systems; on the contrary, every reasonably fruitful procedure should be undertaken and the findings correlated to permit a logical conclusion.

In considering the changes in roentgen diagnosis in the future, probably the most important of all will lie in the field of methods. It is safe to predict that great advances will be made in the next decade in both fluoroscopy by the ordinary means and in photography of the fluoroscopic image. The probability is strong that an electronic method of enhancing the intensity of the fluoroscopic image will become a practical device within the next few years. When this occurs, fluoroscopy may be increased enormously in its value and scope and consequently there may be a rather striking change in the methods of roentgenologic practice.

With the efficiency of the fluorescent screen greatly enhanced, the amount of energy applied may be diminished and the danger from fluoroscopy thereby appreciably reduced. As a result, it may be possible to use fluoroscopy to a much greater extent than at the present time. Furthermore, it may be feasible to change the nature of the crystals used so that more detail will be visible. To the great advantages that fluoroscopy now has in its dynamic character, in the ability to rotate the patient to almost any angle, and in the possibilities of manipulation, will be added some, at least, of the detail which now is available only in the roentgenogram. Changes in the visual image scheme in the

fluoroscopic room may make fluoroscopy a much more pleasant procedure under much lighter conditions. The possibility that the television principle may be applied to fluoroscopy is not too remote; if that were to become true, many of the hazards and unfortunate side-effects of the procedure might be eliminated.

The possibilities of cinematographic fluoroscopic film would no doubt be enormously enhanced by changes in the character of the screen itself and, especially, by amplification of the illumination. It does not seem at all impossible that a motion picture of the fluorescent image may be obtained in almost any case with very little effort. This would permit one of the most desirable means of diagnosis; namely, the careful, leisurely study of the fluoroscopic findings after completion of the examination. Far better consideration might be given to all of the findings if they were enlarged and recorded graphically upon a motion-picture screen.

Improved photographic media together with improved equipment of other types will without doubt permit radiography of much better detail, even of the deeper structures. This may possibly permit us to make earlier diagnoses of metastasis to the spine, for example, a lesion too frequently invisible in the ordinary roentgenogram of today. Similarly, changes in the soft tissues which denote acute osteomyelitis in its earlier stages may become apparent. Soft-tissue radiography will in all likelihood be improved to a large extent during the next decade; such changes may lead to an earlier diagnosis of bone tumors or osteomyelitis and to the diagnosis of many soft-tissue lesions hitherto untouched.

The further development of body-section roentgenography and other methods of a similar character may well give us the answers to some diagnostic problems, particularly in the skull, the spine, the abdomen, and the chest, which still escape us. There is no doubt that body-section roentgenography is still short of its ultimate possibilities; the development of equipment which would permit localization in a simple way, so that a smaller number of roentgenograms would suffice to demonstrate the exact plane of the lesion, would make this a more practical procedure. It would doubtless aid in the diagnosis of many abnormal processes which are now difficult to demonstrate effectively.

The question as to whether better differential diagnoses can be made than at the present time is much more problematic. It would be a great boon if, for example, methods were devised to permit accurate differentiation of lesions in the lungs, so that there would be less doubt as to whether a lesion were tuberculous, pneumonic, or neoplastic. It is exceedingly doubtful that much will be accomplished in this field, in view of the fact that the pathologist, after hundreds of years of study, is still not always able to make an accurate differential diagnosis between such lesions even with the gross specimen in his hand, but must wait for microscopic sections or bacteriologic studies before definitely determining the etiological factor. Nevertheless, some improvement along this line may well occur, however slowly. Likewise in diseases of the stomach, it is conceivable that additional procedures may improve the differential diagnosis.

More detailed views of the stomach and the entire gastro-intestinal tract would be a great improvement and can be expected. As a consequence, the diagnosis of minor mucosal changes such as gastritis or enteritis, will be more accurately made by roentgen study than at the present time.

A revision of our methods of examination in order to learn more about the minor abnormalities in organ physiology would be of great importance and is to be expected, although it may require many more years of study. The ability to detect minor changes in function would lead to a marked improvement in the results of roentgen examination, particularly of the small bowel and the colon. We may be able to devise more exact measurements of functional states than are now possible,

in which event many symptomatic processes, not now recognized as organic, may be more definitely established. There are, obviously, strict limitations to the usefulness of the roentgen method, largely determined by the limitations of what is visible in gross pathologic diagnosis. But the possibility of studying functional disorders roentgenologically may well permit us to go beyond the limits of pathology in the detection of abnormal states.

The recent advances in the use of photofluorography and its application in mass surveys of normal persons may bring about distinctive changes in roentgenologic practice. The routine fluoroscopic examination of many individuals over a period of time has already revealed early symptomless lesions which may be detected in this fashion. Likewise, the results of mass photofluorography are already apparent in the discovery of tumors, inflammatory lesions, and cardiac conditions which were not apparent to the person affected.

A similar type of routine examination, probably more circumscribed, may well be applied to diseases of the stomach. The results of the routine examination of patients with pernicious anemia have been so striking that this type of procedure should be extended. Probably all persons with achlorhydria, or with familial histories of achlorhydria, pernicious anemia, or cancer of the stomach, should be included in groups which should have routine roentgen studies of the stomach.

All of these examinations of apparently normal or symptomless persons must inevitably lead to the exhibition of lesions at an extremely early stage, much earlier, in the mass, than we have been accustomed to encounter. Such a development will lay a much greater responsibility upon the radiologist, who will be forced to make a diagnosis on much less evidence than at the present time. A sharpening of our acuity of observation and of our perspicacity in analyzing the significance of certain shadows must inevitably follow if the fullest advantage is to be taken of these routine examinations.

Better methods for the application of contrast media to organs in which such substances are already in use may be expected. Moreover, the extension of the usefulness of the artificial contrast method to organs which are now roentgenologically invisible seems certain to occur. Such advances have already been discussed.

One more change in the practice of roentgen diagnosis which is highly desirable may well occur in the next decade, as the number of radiologists and technicians assumes a ratio to the population much more in accord with the importance of the specialty. It may be possible to give slower, more careful, individual study to the patient who is sent in for roentgen examination. A rapid x-ray examination of the stomach, for example, often taking not much more than two or three minutes, while it is remarkably effective and accurate in the right hands, does not permit the best type of medical roentgenologic work. The same is true throughout the whole gamut of x-ray examination. In general, the average roentgenologist and the average hospital roentgen department is handling far too large a volume of patients, much too rapidly, considering the importance of the examinations which must be made. The result is that, with the necessity for speed, not all of the facilities at our disposal are commonly used. There is no reason why more body-section roentgenography should not be done, why more examinations of the chest in a variety of positions should not be undertaken, why more patients should not be examined with contrast medium in the joints, in the lungs, or elsewhere in the body. The matter of expense obviously comes into the picture, but some means must be obtained for reducing the tempo of work which the average roentgenologist is compelled to sustain.

Fifty years of unparalleled accomplishment lie behind us. With but few exceptions, the roentgen diagnosis of advanced disease and of gross abnormalities has been firmly established within the limits which are intrinsic in the nature of the process.

But the future is not foreclosed; there is much still to be accomplished. The diagnosis of disease in its incipiency, before it has manifested itself by symptoms, has yet to be widely established. The determination of the nature of many functional disorders, of disturbances in the physiology of organs without obvious pathological change, remains to be clarified. Nothing in the field of medicine is more dynamic or susceptible of improvement than roentgenology.

As we attempt to emulate the achievements of the past half century, it is well within the realms of probability that the answers to many of the remaining problems, which lie within the realm of our present knowledge, will be obtained. Who can foresee what new ideas, what new problems, entirely outside the limited perceptions of today, will present themselves on the hundredth anniversary of Röntgen's discovery?

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The Development of Roentgen Therapy During Fifty Years

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THE FIFTIETH anniversary of the discovery of "the new kind of ray" by Professor Wilhelm Conrad Röntgen demands a survey of the great benefits that were thereby conferred upon mankind. Many of the details in the earlier development of roentgen therapy, preceding 1933, have been so well covered by Dr. U. V. Portmann (50) in the "Science of Radiology" that it would be superfluous to repeat them here. Because of the brevity of this review, also, it will be impossible to do justice to all who have made valuable contributions to the progress that has been made in roentgen therapy.

Professor Röntgen, the modest and true scientist, when he discovered this "new kind of ray" in November 1895, did not immediately proclaim it from the housetop. Instead he was anxious to study the characteristics of these rays thoroughly before making an announcement. Not even his two assistants knew of the discovery. He handed his "preliminary" paper "On a New Kind of Ray" to the President of the Würzburg Physical Medical Society (57) on Dec. 28, 1895, and it was included in the *Annals* of the Society for that year.[1] A friend scientist to whom Professor Röntgen had sent some of his first x-ray pictures loaned them to another friend, who without consent had the story published on Jan. 6, 1896, in the *Wiener Presse*. Immediately thereafter announcements were made throughout the world, in the newspapers and in scientific journals, but apparently Röntgen made but a single public address on the subject, on Jan. 23, 1896, before the Physical Medical Society of Würzburg. The importance of both the physical and medical aspects of his discovery is emphasized by the presentation to this combined society. It was at this meeting that von Kölliker proposed that these unknown or "x" rays be called "Röntgen rays."

Professor Röntgen published two subsequent scientific papers (58, 59) to record his complete investigations, but immediately after the publicity given, without his knowledge or consent, on Jan. 6, 1896, teachers of physics throughout the world repeated these demonstrations in their own laboratories. As a matter of fact, x-rays were being produced in every laboratory of physics where high-tension currents were being passed through Crookes tubes, and some of the photographic effects were recognized even before Röntgen's discovery (Fig. 1), but were not sufficiently investigated. I myself recall seeing the characteristic greenish light of a Crookes tube excited by a static machine in the demonstration of matter or gas in the "radiant state" by Prof. L. G. Cope, in a lecture on physics in 1893, at the Teachers College, Bloomsburg, Pa. This was my first but unrecognized experience with x-rays.

With investigations of the nature, characteristics, and applications of these new rays being carried out all over the civilized world, it is difficult, if not impossible, to establish priority in their use for the treatment of disease. It is equally difficult to give due credit to each investigator who has made a contribution to the extraordinary progress of roentgen therapy during the past fifty years.

Twenty-three days after the newspaper announcement of the discovery of the new rays, the first investigation of their therapeutic value was suggested in a letter to the London *Lancet* by T. Glover Lyon (36), who believed they might have a destructive effect on the tubercle bacillus. His own investigations and those of others soon proved, however, that except in enormous

[1] This paper and the subsequent one are reprinted, in translation, in this issue of RADIOLOGY (pp. 428–435).

and impractical doses the rays have no bactericidal properties. Professor Rieder (who later originated roentgen diagnosis in gastro-enterology) showed as early as 1898 that the beneficial effects of roentgen therapy in infectious diseases were due to the action on the tissues of the host (56).

According to the records of E. H. Grubbe (19) of Chicago, he began x-ray treatment of a cancer of the breast by Jan. 29, 1896 (twenty-three days after the announcement of the discovery in the newspapers), and the next day applied the rays to a case of lupus vulgaris. Grubbe was at that time a manufacturer of Crookes tubes, and the patients were referred to him by two physicians on the staff of the Hahnemann Medical College (Chicago), where his hands were being treated for a dermatitis evidently due to exposure to the rays. Roentgen therapy thus began almost exactly with the discovery of the rays and, so far as is known, was first practised in America.

The interest and enthusiasm aroused by fluoroscopic examinations with the new rays and the absence of any accompanying sensation led to frequent over-exposure and damage, especially to the skin of the faces and hands of the investigators, with a resultant dermatitis, while over-exposure of the scalp in examinations of the skull was followed by alopecia. These effects suggested to many investigators a possible therapeutic value.

L. G. Stevens (65), on April 18, 1896, Feilchenfeld (Lichenfeld) (35) in May 1896, and H. R. Crocker (8) were the first to publish opinions on the "sunburn" or "eczema" caused by the roentgen rays. Early in 1897, T. C. Gilchrist (15) of Johns Hopkins Hospital, Baltimore, collected from the literature 23 such cases; three months later N. S. Scott (61) of Cleveland found 69 examples, and in 1900, E. A. Codman (5) collected 170 cases of roentgen injuries, which proved that the rays had a pronounced biological effect.

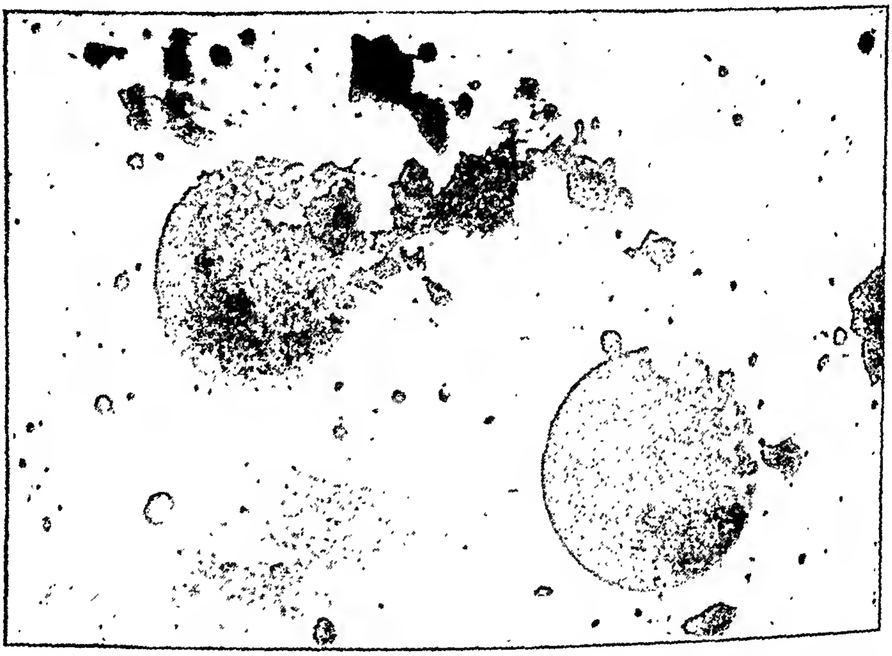


Fig. 1. The first shadowgraph, made accidentally by Prof. A. W. Goodspeed of the University of Pennsylvania while working with the rays from a Crookes tube, February 1890.

The progressive skin effects were recognized by all careful observers relatively early. They are classified, depending upon the degree of effect in the acute stage, as *first degree*, with erythema, pigmentation, and recovery; *second degree*, with erythema, vesiculation, desquamation and recovery; *third degree*, with erythema,

vesiculation, ulceration, necrosis, excision, and recovery. In the *chronic cases,* an erythema may or may not be present, but there are atrophy, telangiectasis, splitting of the nails, hyperkeratoses, warts, fissures, and late ulceration, often with the ultimate development of carcinoma.

It was the epilating effect of the roentgen rays which led scientifically and logically to their use in therapy. On April 10, 1896 (three months after the announced discovery), J. Daniel (9) of Vanderbilt University reported the loss of hair from the head of a colleague whose skull he had "photographed with the x-rays." On July 22 of the same year, W. Marcuse (37), in Berlin, published his observations on a patient who had severe skin reactions including epilation following prolonged and frequent exposures to roentgen rays for public demonstrations. Upon the basis of these reports, Leopold Freund (12) used the rays in treating a young girl with a disfiguring hairy nevus. The result was reported to his local medical society on Jan. 5, 1897, just about a year after the discovery of the roentgen rays was announced.

Following the wide publicity given to Freund's report, roentgen rays were used enthusiastically for their therapeutic effect, especially in skin diseases. Priority for their use in specific conditions is given by Kienböck (30) as follows: "hypertrichosis, Freund, 1897; lupus, Kümmel and Schiff, 1897; lupus erythematosus, Schiff, 1898; psoriasis, Ziemssen, 1898; chronic eczema, Hohn, 1898; epithelioma, Sjörgren and Stenbeck, 1899; alopecia areata, Kienböck, 1900; superficial sarcoma, Ricketts, 1900; mycosis fungoides, Scholtz, 1902; leukemia and lymphadenoma, Pusey and Senn, 1903."

At the time of the discovery of the x-rays the essential equipment was available in every well established laboratory of physics, consisting of Ruhmkorff or Tesla coils or the static machine used to produce the necessary high-tension current. The second essential was the Crookes tube. These rudimentary essentials were quickly produced or modified for use in diagnostic work in hospitals and the offices of physicians. The observations on the incidental or damaging biological effects led to the use of the same equipment for therapeutic purposes.

To the modern roentgenologist, this rudimentary equipment must seem absurdly inadequate and, of course, grossly dangerous. The bare clear glass tube was used with no protection either to the patient or the operator. It is not surprising that many of the early workers died from the damaging effects. The volume of the current was very small, so that one heard of exposures of three hours to make a "picture of the hip joint or the kidney." As a result, there were many serious injuries, because the heating of the tube softened the rays and most of them were absorbed in the soft tissues. In 1899, when I began my work at the Philadelphia General Hospital, I was fortunate enough to obtain "a very powerful coil" from Leeds and Northrup Company in Philadelphia, which permitted me to make a "picture" of a hip or a head in eight minutes. At that time, I was interested in diagnosing brain tumors (42) and made two "pictures" of my assistant's head to get a record of the normal in a living subject. In two weeks a complete alopecia of the left side of the head developed, but in three months the hair was entirely restored. It was such experiences that gave some idea of dosage values. We had no voltmeters and no milliampere meters. The voltage was estimated by the length of the point-to-point parallel spark-gap and the intensity of the current, and the penetrative quality of the rays was judged by the appearance of the hand held in front of the fluoroscope. This test led to the loss of the fingers, hands, and even the lives of many of the pioneer workers. The ammeter and the milliampere meter (d'Arsonval) were soon developed to measure the volume of current, and the spintermeter (Béclère) for measuring the spark gap or voltage. The intensity of the irradiation and the dosage were determined by photographic effects (Kienböck) or the darkening effects on barium platinocyanide

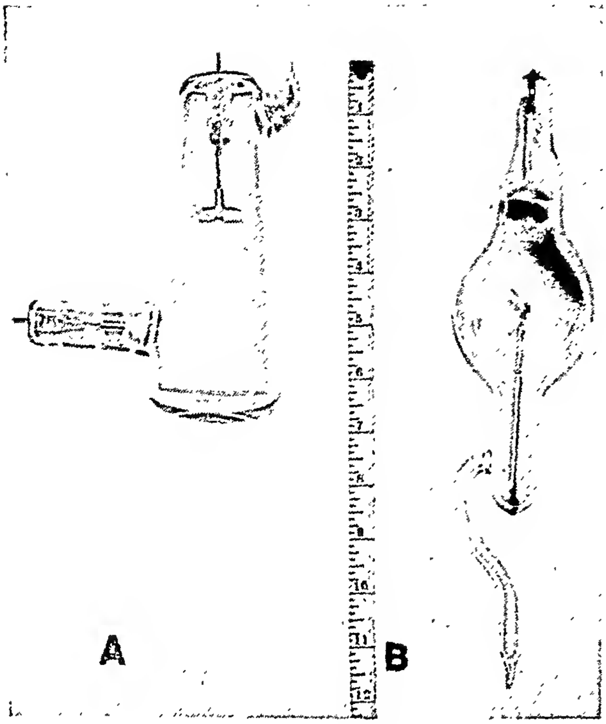


Fig. 2. A. Crookes tube, reproduced by Dr. H. C. Rentschler, Westinghouse Electric & Mfg. Co., from designs furnished by Dr. Mutscheller, to represent the type of tube used by Röntgen in his discovery of the rays. Observe that the target was the bottom of the glass tube.

B. One of the tubes used in the Medico-Chirurgical College laboratory by Dr. M. K. Kassabian. This tube, made in 1897, has a cup-shaped cathode and an iridio-platinum target.

The size of these tubes is indicated by the tape measure (in inches). It will be observed that the bulb of the tube shown in B is not more than 3 inches in diameter.

disks (Sabouraud and Noire, Holzknecht, Bordier, Hampson) (50).

The x-ray tube was at the beginning the customary Crookes tube used in the physics laboratory, merely a glass tube exhausted to a high degree of vacuum with simple electric cathode and anode (Fig. 2, A). With a view to increasing the intensity of the rays from a point, the cathode was soon made cup-shaped, directing the beam of cathode rays to a point on the anode consisting of a disk of iridioplatinum (because of its high melting point) (Fig. 2, B). It is impractical here to review every step in the development of the modern therapy tube, and to give due credit to each contributor, but gradually the tube was made larger and the anode heavier, with iridioplatinum central disks in a mass of copper with large supports and external radiators or water-cooled stems to carry off the heat. Elsewhere in this journal[2] details of tube development are described by Dr. W. D. Coolidge, who has played so important a part in this respect.

When large copper anodes came into use, gases given off from the copper reduced the vacuum and the penetrating quality of the rays, which explains many failures in deep therapy in the early days. I commonly used four different tubes to give a single treatment (about 20 per cent of an erythema dose). In spite of this primitive equipment and primitive technic, much progress was made.

During the first ten years after the discovery of roentgen rays, dependence was placed upon larger Ruhmkorff coils or larger static machines to produce a greater volume of high-tension current. (I used a large 16-plate static machine for part of my early therapeutic work.) The vibrating spring interrupters and the electrolytic interrupters limited the amount of current and were a source of much difficulty, while the atmospheric conditions caused much trouble with the static machines. Even at this early stage, Eugene Caldwell, who gave us the Caldwell electrolytic interrupter, had made some progress in the use of valve tubes in the alternating and the three-phase current.

A great step in advance was made by Clyde Snook (1905) when he produced the *interrupterless coil.* This consisted of a motor-driven rotating high-tension switch by which the higher voltage portion of the sine wave was reversed so as to carry the high-tension current into the tube in one direction. This gave a tremendous increase in the possible volume of current and enabled us to shorten diagnostic exposures to seconds, but the prolonged exposures necessary in therapy with the increased volume of current soon over-heated the available tubes in spite of their large size, large anodes, radiators, and water cooling. It was during this period, also with the use of the 16-plate static machine, that I had to use four gas tubes to give a single treatment.

[2] See page 449.

and preserve my penetrative values or depth dose.

The next great step in advance was the development in 1913 of the *hot-cathode tube* by our distinguished colleague and friend, W. D. Coolidge (6). This vacuum tube has been improved or enlarged so as to adapt it to many requirements, but in principle it remains the standard today. Basically it consists of a tungsten anode (from the development of ductile tungsten by Dr. Coolidge) and a cup-shaped cathode in which a small coil of molybdenum wire is heated so as to give off electrons with which to bombard the target and produce the roentgen rays. By regulating the amount of low-voltage current passing through the cathode filament, the number of electrons can be controlled and the degree of vacuum or penetrating power of the rays can be controlled and kept constant for any desired volume of current. This constancy in volume and quality of rays has enabled the radiologist to duplicate more closely his own diagnostic and therapeutic results in different patients and at different times, and has made possible descriptions of technic so that similar results could be obtained by others all over the world, with due allowance for variations in biologic response to identical dosage.

BIOLOGICAL EFFECTS

Carefully controlled investigations as to the cause and degree of the biological effects of the roentgen rays began soon after their discovery. Elihu Thomson (66) of Boston, in November 1896, announced his experiment to prove that a dermatitis developed in only that part of the body actually exposed to the rays. Kienböck (29), in 1900 irradiated rats enclosed in metal cylinders to exclude light and electrical effects, thus proving that the effects were the direct result of the rays.

Among the first and best studies of the histologic effects of the rays on the skin were those of A. B. Kibbe (28), of Seattle, Washington, and Gilchrist (15) of Johns Hopkins Hospital, published in January and February 1897, respectively. The latent period and the cumulative effects of the rays on the skin were also recognized in these early days.

The variable effects on different tissues and different types of cells were likewise demonstrated. In 1903, Albers-Schönberg (1) showed that aspermia could be produced in experimental animals by roentgen rays without injury to the overlying skin, which at once proved a striking difference in the sensitivity of different types of cells. This differential effect was established in more detail by Heineke (21), whose report appeared a few weeks later. To him the lymphoid tissues appeared to be especially radiosensitive, and he suggested that roentgen rays might be useful in the treatment of leukemia, without knowing of the beneficial clinical results already obtained by Senn (63), who established definitely the value of deep roentgen therapy.

In 1904, Bergonié and Tribondeau (4) gave a complete histologic picture of the change produced by irradiation in the rat's testicle, showing the focus of attack to be the embryonic structures. They then formulated the law, known by their name, which is the basis of our knowledge of the effect of the rays upon all cells and tissues: "*Immature cells and cells in an active stage of division are more sensitive to radiation than are cells which have already acquired their adult morphological and physiologic characters.*" These observations were supported by similar studies, by Halberstädter (20), of the effects of irradiation upon the ovaries.

IDIOSYNCRASY

Idiosyncrasy has been a debatable subject from the beginning of roentgen therapy. For the most part, it has been discussed from a clinical standpoint. It must be admitted that in the early stages the variable effects observed depended upon lack of instruments for the accurate measurement of the essential factors governing the intensity of radiation, or lack of knowledge of the biological effects to be expected. On the other hand, there can be no doubt that there is a great difference in the effect

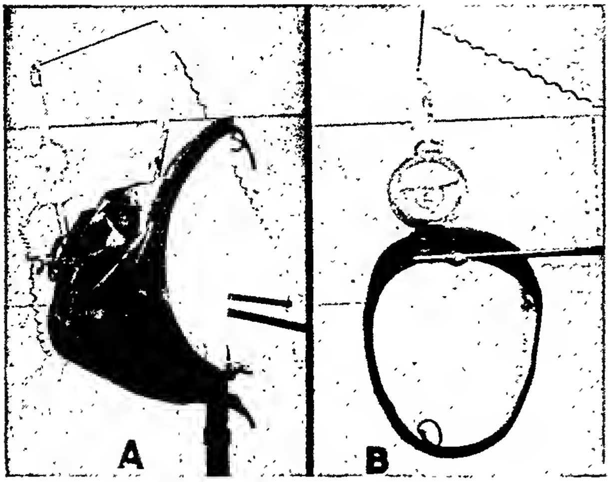


Fig. 3. A. Small aluminum screen with the tube darkened with a black cloth. The holder was an adaptation of a photographic headrest, and in no way grounded, and now definitely used for filtration value. The illustration shows the self-regulating spark gap used to keep the vacuum constant. In B the filter and darkened cloth are turned downward for demonstration of the tube itself from the front.

of measured doses on individuals as observed clinically and as shown experimentally. From the very beginning of experimental work to the present, it has been found that when animals or insects of a known strain and age are exposed in mass to radiation of the same intensity and quality, not all are killed by the so-called "fatal dose," while some fail to survive even a relatively small fraction of the "fatal dose." The difference between the lowest and the highest lethal fatal dose proves the possibility of idiosyncrasy, or extreme sensitivity.

FILTRATION

The injurious effects of the roentgen rays on the skin were recognized by a few men almost immediately after their discovery. Even before this, damage had occurred to men who were making Crookes tubes. Many roentgenologists, and their assistants and patients, however, suffered serious injury before this danger became generally known. Early in the history of roentgenology, these effects were thought by some to be electrical, and grounded aluminum screens were placed between the tube and the patient. In 1899, at the Philadelphia General Hospital, I placed an aluminum screen, 6 × 6 feet and about 2 mm. in thickness, between the tube and the patient and myself, not for protection from the rays but to carry away any electrical currents and as a transparent support for a cloth draped over the tube and the tube stand. A few months later, this large aluminum screen was replaced by a small one attached to the tube holder, and no longer grounded (Fig. 3). *It must be remembered that at this time open gas tubes were used with no protection*, not even the glass bowl (Figs 4 and 5). To this device, which gave me some protection in the great amount of fluoroscopic work which I was then doing I attribute the preservation of my life I was not only studying the many patients in the Philadelphia General Hospital but I conducted repeated fluoroscopic examinations on interesting cases for demonstrations to the thirty-two resident physicians The above device enabled me to demonstrate to groups and thus saved time and limited the amount of exposure.

In 1904, Perthes (40) made the first "depth dose" measurements, which subsequently led to the use of filters in Continental Europe. His studies led him to the following significant conclusion: "When irradiating the body, the intensity of the roentgen rays diminishes very rapidly from the surface to the depth; the decrease of intensity in the depth is much less if an absorbing layer, *i.e.*, 1 mm. of aluminum is placed on the surface of the body." As stated by Portmann, "this work of Perthes led to more thorough investigation of the absorption rate in various media and to the immediate suggestion of the use of homogeneous rays in roentgen therapy as developed within the next few years by F Dessauer." Perthes' work was not known in America, or at least not to me. My first thought of "filtration" was inspired by the report of the physicist, Walter, in 1905 (69), and I immediately made experimental and clinical investigations which were presented before the American Roentgen Ray Society in September 1905 (43). (Recently I have found a preserved skin from the back of a rabbit used then to test

the value of leather filter. See Figure 6.) My reasoning, as expressed at that time, was based on Röntgen's statement, in his third communication (59), that the x-ray 's composed of rays of different quality nd that the second layer of any subance absorbs very much less of the rays n are absorbed by the first layer. lter having confirmed the correctness of Röntgen's original observation, concluded further that "all substances have respectively a selective absorbing power for the rays." Recognizing the above hysical laws, namely that each substance is a definite and peculiar absorbing power the roentgen rays, and that the rays which have once passed through a substance are less likely to be absorbed by a second layer of the same substance, I decided to make a practical application of these principles. At that time the rays which gave us most concern were those that affected the skin when we were treating deep-seated disease. I reasoned that, if the law of selective absorption were correct, the skin would absorb the rays peculiar to itself, and that to remove such rays it was necessary to interpose a filter similar to skin (Figs. 7 and 8). Wet sole leather was thicker but most nearly resembled the skin. This was found effectual, and a dose that would ordinarily cause necrosis of the skin could be given without damage, thereby permitting an increased depth dose and an improvement of clinical results.

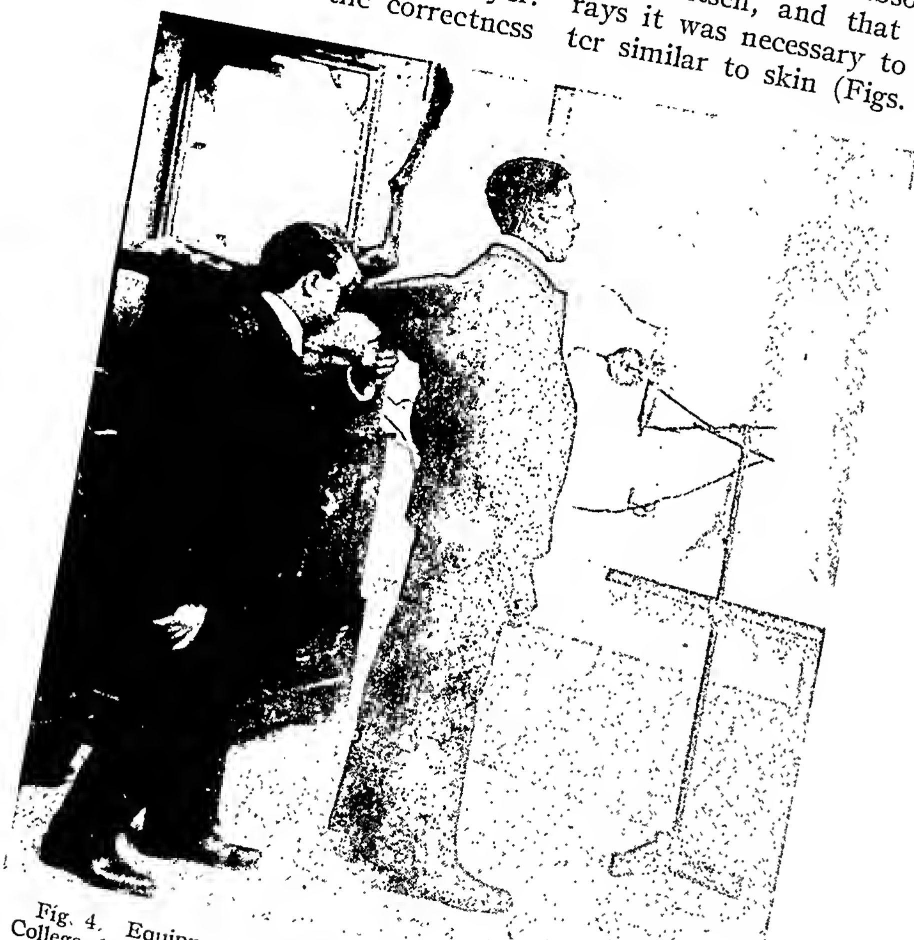


Fig. 4. Equipment and type of tube used at the Medico-Chirurgical College, 1900. Dr. M. K. Kassabian is using the hand fluoroscope with no protection to the patient or the physician. Dr. Kassabian later died from carcinoma secondary to radiation effects.

During the following years, my colleagues throughout this country and in Europe used this filter. We gradually learned, however, that the "peculiar rays"

were not so definite, and the leather filter was abandoned, increasing thicknesses of aluminum being used to remove the softer rays and adapt the quality to the biological effects desired at a given depth.

Gradually our physicists and manufacturers made equipment giving increasing penetration and rays of progressively shorter wave length, permitting a relatively increased depth dose as compared with the effects on superficial tissue. The necessary brevity of this review prevents giving due credit to each contributor or mentioning the detailed steps which were necessary in making these improvements. They are recorded in the mass of roentgen literature which has accumulated during these fifty years.

As higher-voltage rays became available, filtration was also increased. It became evident that after about 4 to 6 mm. of aluminum were necessary (and generally used with low-voltage therapy), the quality of rays or depth value was not greatly increased. At this point copper proved to be better, and after 0.5 to 1 mm. of copper was necessary in so-called "high-voltage therapy" (150 to 200 kv.), tin was found by Thoraeus (67) to be more effectual in improving the quality, as used in the combination Thoraeus filter of tin, copper, and aluminum. This latter filter gives about 25 per cent greater intensity of radiation than the qualitatively equivalent copper filter. As we have gone into the super-voltage field (400 to 1,000 kv. or more), copper, tin, and lead are being used in increasing thickness, and with the hope of developing rays equivalent to the gamma rays from radium.

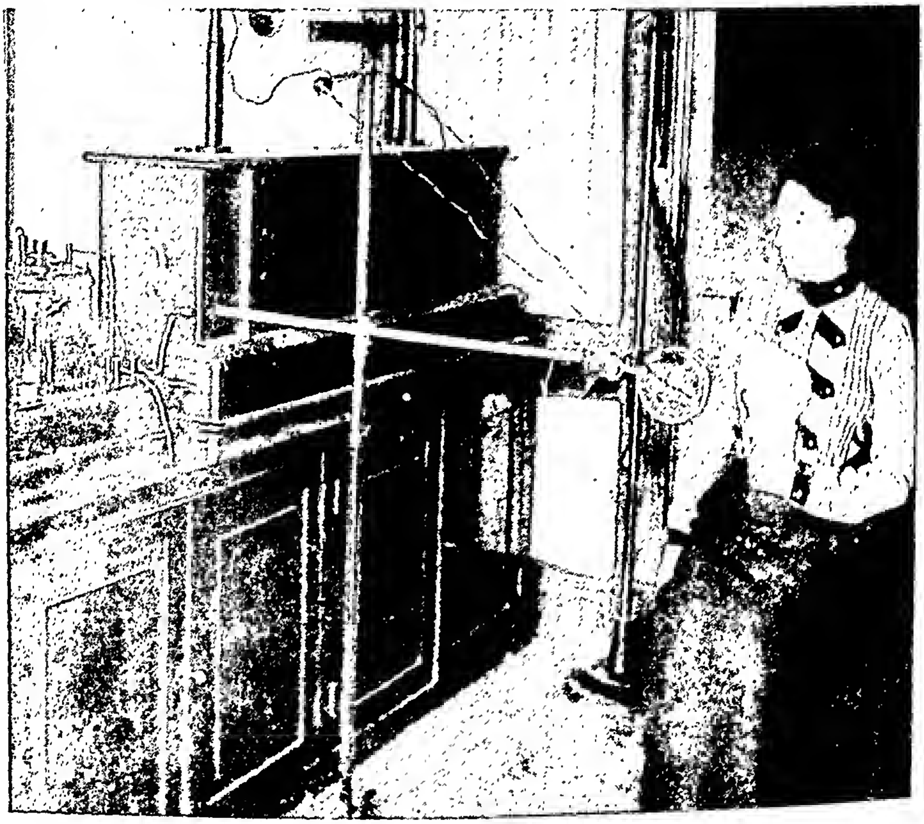


Fig. 5. Early type of equipment used therapeutically. The "naked" or unprotected tube is being used in the treatment of a recurrent carcinoma of the breast. The patient is holding a lead shield which evidently protects the skin immediately surrounding the lesion, but it can be seen that the hand and the surrounding parts of the body are receiving a very considerable proportion of the radiation. From Monell (38).

While it is true that with higher voltages and increased filtration a greater proportion of rays can be delivered to any given deep point, it would seem that there must be a

limit to the usefulness of increasing penetration. The effectual rays in any given tissue or depth would seem to be those which are absorbed, not those which merely pass through the tissue. It also seems to me that it is wise to use that quality of rays which will have the greatest possible biological effect on the tissue under treatment and at the same time do the least damage to the surrounding tissue, either proximal or distal to the disease, and to essential organs.

The damaging effects on the skin, the demonstration of the value of filtration, and the damage to the gonads and to the body as a whole led naturally to the development of protective devices. The control switches or panels were placed as far away from the tube as possible, first behind lead screens in the same room, then in leaded booths, and finally behind leaded walls in a control room fitted with lead glass windows.

The patient was protected by lead diaphragms, which allowed only the necessary beam of rays to reach him (Fig. 7). (I described such a diaphragm as early as 1903.) In the early days we tried to protect the patient by covering with sheets of lead. This was objectionable, and I developed a variable lead diaphragm which did not touch the patient but still gave protection. A little later, I added lead shields at the edges (Fig. 8). Then, to get better protection, metal tube stands or table supports were developed, holding heavy lead glass bowls. Further protection was later obtained by immersing the entire tube and high-tension apparatus in a grounded metal oil container—on a small scale, the dental outfit (presented by W. D. Coolidge at the meeting of the American Roentgen Ray Society, at Saratoga, 1912), and on a large scale (by the General Electric Mfg. Co.) in the "Maxmar" 400 kv. outfit for supervoltage therapy. "Supervoltage" rays were also developed by the use of cascade tubes, using 1,000 kv., but these required a separate large building (6 stories, Pasadena) and only the beam of rays entered the treatment room. Smaller equipment was then developed, still using 1,000 kv. or more.

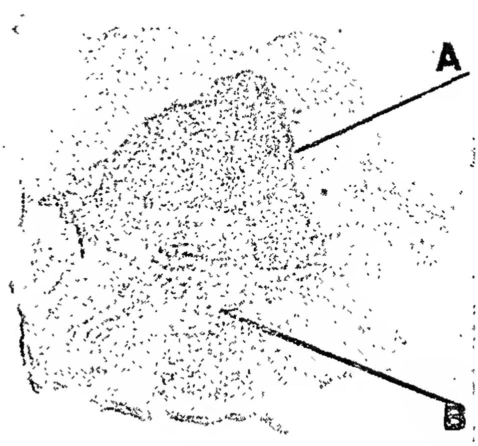


Fig. 6. A portion of the skin of the back of a rabbit used to test the filter value of wet sole leather. The upper half of the exposed area shows (A) deep ulceration. This area was treated with unfiltered radiation for the same length of time, and identically with the area indicated by B. This latter area was protected by wet sole leather which covered half of the lead diaphragm. There is complete epilation but no ulceration, proving definitely the value of filtration. The area treated is not sharply defined because there was naturally slight movement of the rabbit skin during the exposure.

The greater focal skin distance possible with the large volume of roentgen rays from supervoltage equipment probably gives them a great advantage over gamma rays from radium because of the greater depth dose. Much expense is involved, but this is far less than even a fraction of the cost of radium, when account is taken of the volume and intensity of radiation obtained from the supervoltage outfit.

"Supervoltage" (above 200 to 250 kv.) roentgen rays are still under serious and extensive scientific investigation. These rays undoubtedly are of superior value in selected cases but they cannot be used to replace "low-voltage" (50 to 150 kv.) or the "high-voltage" (150 to 250 kv.) rays. These latter types I believe will always be used for the great bulk of work.

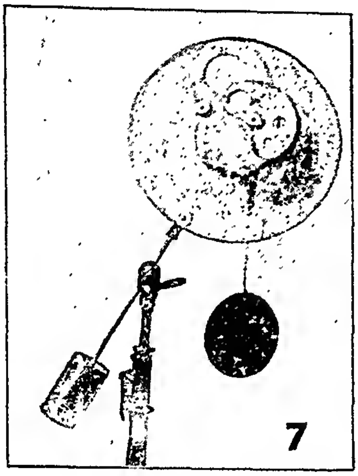
Three principles must be borne in mind: (1) We must use rays of such quality as will be absorbed in great part by the diseased tissue. (2) We must use rays with sufficient penetrating value to reach the

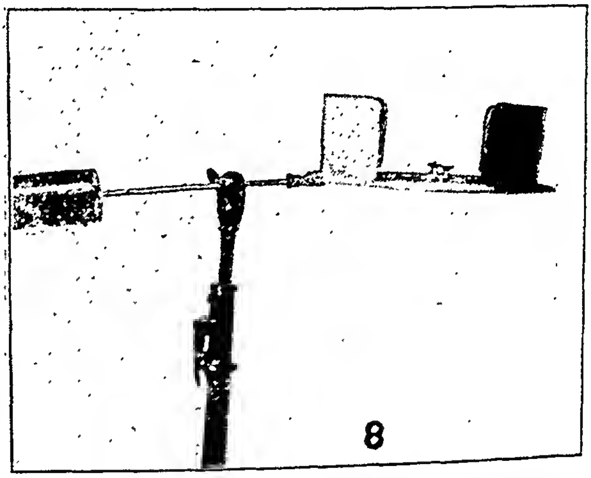
diseased area without doing too much damage to the overlying tissue. (3) We must use a quality of rays and equipment which will permit us to deliver the beam to the diseased area as accurately as possible and inflict a minimum of damage on the surrounding tissue. The lower voltage rays, therefore, have certain definite advantages.

DOSAGE

The development of dosage values has been and still is a difficult problem. Its solution has been considered and developed first from a biological and second from a physical standpoint. The dosage at first was judged by the radiation effect on the skin—epilation or erythema. This was before we had any measuring instruments. Each observer had to take account of the time required with his apparatus to produce epilation or erythema (1st degree), vesiculation (2d degree), or ulceration (3d degree), and be governed by this in other cases. Such information and experience could not be easily imparted to other radiologists nor depended upon as applicable to other machines. At the beginning, nothing was accurate except the factor of time. We had no voltmeters, no milliampere meters, nothing except individual experience. One will find, in the early records of technic, such absurd statements as "The exposure was ten minutes," or "A normal dose was given," just as today we find the equally absurd statements: "Radium was applied for twelve hours" or "25 milligrams were applied for twenty-four hours."

Improvement followed the development of the low-voltage ammeter, the high-voltage milliampere meter, and the voltmeter and we then learned to record the *time distance, milliamperage, kilovoltage, filtration,* and *size and location of the portal* With these known factors, a fair degree of accuracy was possible. The dosage could be duplicated and the information could be transferred to other radiologists.





Figs 7 and 8. Fig. 7 shows a lead protecting device 15 inches in diameter with adjustable circular diaphragms in the center, designed by myself in 1903, counterbalanced. The largest opening in this diaphragm corresponded to the size of the largest disk which could be moved out of position completely. Hanging from a string (for purpose of illustration) is a circle of sole leather used as a filter.

Fig. 8 shows the next step in protection furnished by the lead shield fastened to the edges of the lead diaphragm. The use of this was possible only because the shield was insulated by standing on a wood floor.

The early methods of measurement are described by my classmate, M. Kassabian (25) in his book, published in 1907. These included the factors mentioned above and are usually referred to by roentgenologists as "the indirect method" of measuring dosage. The direct method requires a measure of intensity and the total value of radiation reaching the affected tissues—at first, the skin. The first means of measuring the direct amount of radiation on the

skin consisted of disks of barium platinocyanide, the color of which changed from a greenish yellow or lemon color to a deep orange hue. This means of direct measurement was suggested by the fact that barium platinocyanide fluoroscopic screens changed color in this fashion after much use. Sabouraud and Noire, who used roentgen rays extensively for the treatment of ringworm of the scalp, found that when they placed one of these disks midway between the target of the tube and the skin, the change to a deep orange *indicated an epilation dose.* Placed on the skin, it registered, of course, four times this dose. The method required fresh or rejuvenated disks, standard lighting, a standard color disk for comparison (Holzknecht, Hampson, Bordier) (50), and accommodation of the eyes to darkness. These basic requirements were difficult to meet consistently, and the method, therefore, was in general unsatisfactory, though it is probably even now in use. As I remember, it was still employed in 1928 as an auxiliary method in the Curie Institute in Paris. For American use the disks were imported from France and, since they deteriorated on the way, they were less popular here than abroad.

Kienböck (29) recommended the use of strips of photographic paper in small black envelopes. His method required a standard paper, standard developer, standard temperature, and comparison with a standard scale, graded in 10 per cent divisons of the erythema dose. Furthermore, the dosage could be measured only after it was given. I used this method for a number of years, by testing and adapting one of our American photographic papers for the purpose. A small portion of the exposed strip, after being developed, was pasted on the patient's record opposite the factors necessary for the "indirect" method of measurement. These records are still available for observation.

It can be readily understood that none of these methods for dosage measurement was satisfactory. They were inaccurate and difficult to employ. They gave no information regarding the depth value, but concerned only the skin effects.

The *ionization effects* of roentgen rays were reported by Professor Röntgen (58) in his second communication, March 9, 1896. At this early date he wrote: "Electrified bodies in air, charged either positively or negatively, are discharged if x-rays fall upon them; and this process increases with the intensity of the rays." This keen observation, made only a few months after the discovery of the rays, is the basis of our present accurate method of measuring the intensity of radiation at any given point in the air, on the surface of the skin, or at a depth in the tissues or in a phantom, with or without inclusion of the secondary radiation. It took many years to develop equipment for the accurate measurement of this ionization—intensity of radiation—for practical daily use. The next requirement was the development and international adoption of a unit of ionization. I regret that space will not permit a detailed account of the various steps in the development of this unit (see the review by J. Cramer Hudson, 23). The earliest proposal of such a unit of dosage was made by P. Villard (68) in 1908. He defined the unit as "that which liberates by ionization one electrostatic unit of electricity per cubic centimeter of air under normal conditions of temperature and pressure."

As early as 1905, Duane (10) had pointed out the effects of radiation from the walls of the ionization chamber and the methods of eliminating these effects. In 1914, he (11) defined his unit of intensity. Small chambers and methods for practical clinical measurements were developed by Duane (11), Krönig and Friedrich (32, 14), Solomon (64), Villard (68), Glasser and Meyer (16), Behnken (3), and others.

The methods and units of measurement developed by the physicists were so accurate and in such agreement that the Second International Congress of Radiology, meeting in Stockholm in 1928, adopted the "*international unit*," and defined it as

lows: "The *unit of dose* is that quantity of roentgen radiation which, when the secondary electrons are fully utilized and the wall effect of the chamber is avoided, produces in 1 c.c. of atmospheric air at 0° C. and 760 mm. mercury pressure such a degree of conductivity that one electrostatic unit of charge is measured under saturation conditions. This unit shall be called the 'roentgen' and designated by 'r'."

The development of an accurate unit of dosage and its international adoption constituted one of the most important steps in the evolution of the scientific clinical use of roentgen therapy. It is true that it required a period of thirty-two years, which again illustrates the truth that many steps and contributions from many minds usually enter into any scientific development.

Originally, even as we do today, we thought in terms of the biological and clinical "erythema dose," but such a concept is inaccurate because it varies with the sensitivity of the skin and with the judgment of the roentgenologist. Great advances have been made, but much investigation is still needed in the development of accurate clinical dosage. This involves a continuation of the collaboration between the clinical roentgen therapist and the physicist. We shall always be grateful to Duane, Failla, Glasser, Meyer, Quimby, Stenstrom, Laurence, Taylor, Weatherwax, and other physicists in this country, and to many in other countries, who have given us so much practical help.

One of the greatest contributions to the scientific advancement of roentgen therapy is the work done by the Committee on Standardization appointed by the radiological societies. We are especially grateful for "Technical Bulletin, No. 1," 1940, prepared by Edith H. Quimby and George C. Laurence (54), who were subcommittee members of the Standardization Committee appointed by the Radiological Society of North America, headed by Lauriston S. Taylor and U. V. Portmann. This *Bulletin*, published in RADIOLOGY (August 1940), contains the basic facts of our technical knowledge to date and its 20 pages of condensed information should be known by every radiotherapist or at least be available for rapid reference. It represents the combined work of our great physicists during the past fifty years.

TECHNIC

In the practical therapeutic application of the roentgen rays, the radiologist must not only take into account the physical factors governing the intensity of radiation and the total amount, but he must consider the biological effect according to the intensity in r units per minute, the duration of the dose if all is given at once—"massive dose"—or the variable effect if the total necessary quantity is given in divided—"fractional"—dosage over a considerable time (two to six weeks), so-called "protracted fractional dose method."

The various methods or technics must be adapted to the conditions which are present in dealing with the individual patient and the special disease under treatment. One must keep in mind the fact that the cells of the body vary in type, and that in disease they have undergone some change, such as inflammation or neoplastic growth, or have assumed abnormal function from causes known or unknown, with consequent disturbance of the organism. Roentgen rays have the power to inhibit function or growth and even to destroy cells, and thus may bring about normal physiologic function.

As a result of clinical observation and researches in biology, it has been found during these fifty years that the different types of cells or tissues of which the human body is composed vary in their sensitiveness to roentgen radiation in the following order: (1) primitive blood cells; (2) germinal cells of the ovary and testicle; (3) blood-forming tissues, including the cells of the red bone marrow, lymphatic system, and spleen; (4) some glands of internal secretion, as the thymus, pituitary, adrenals, and thyroid; (5) the skin and its glands and hair follicles; (6) the abdominal viscera, including the liver, intestines, pancreas, kidney, and uterus; (7)

connective tissue, consisting of muscle, fascia, tendons, cartilage, bone, fat, and nerve tissues.

The reaction or response to roentgen treatment of a disease or neoplasm involving the tissues or organs listed above can be fairly well predicted and the technic must be adapted accordingly. Some lesions are highly susceptible and are radio-sensitive if composed of the *sensitive* types of cells, as those of the lymphatic tissue; others are *resistant* if composed largely of connective tissue, such as fibrosarcoma.

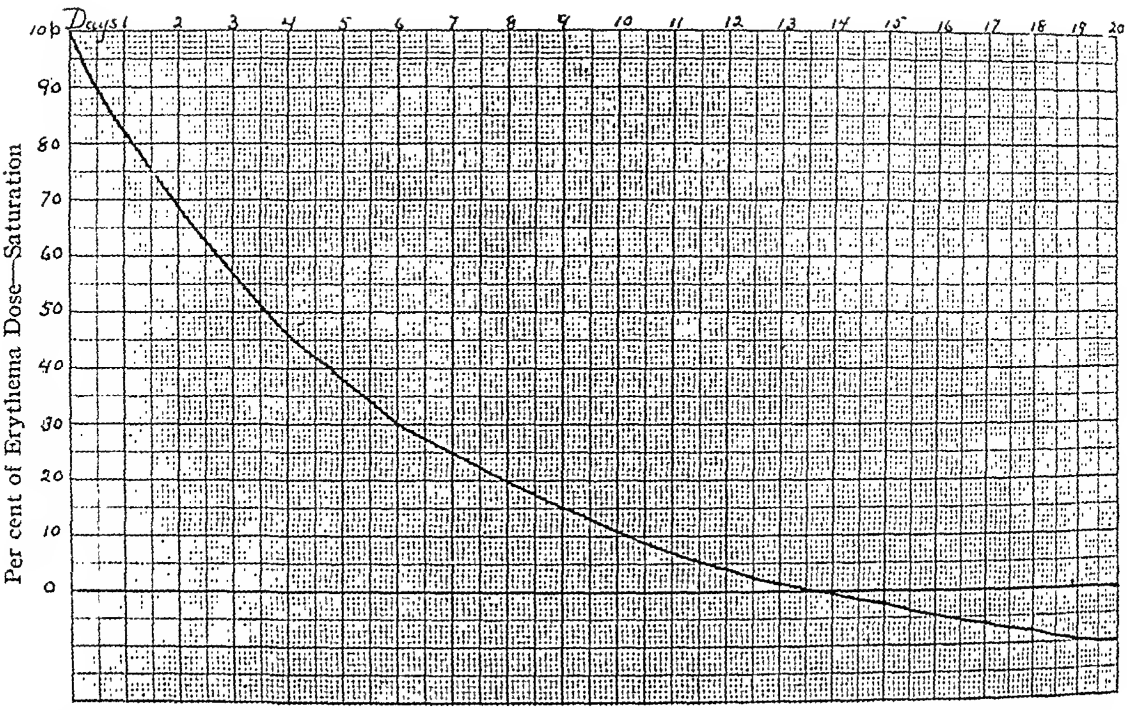
The results obtained during the past fifty years in the roentgen therapy of both superficial and deep-seated disease form the basis for the hope of even greater accomplishment in the future, with improved equipment and greater knowledge of the nature of disease, the biological effects of the rays, and skill in the application of treatment to the individual patient. *Knowledge and skill in the use of this instrumentality are as important as knowledge and skill in the use of the instruments in surgery and are more difficult of attainment because the immediate effects cannot be seen.*

After the physical "indirect method" of measuring dosage had been developed, it was essential to determine the best method of clinical application in each particular disease. Such problems as the following were involved: Should the full dose be applied at one seance or should divided small doses be given? How large should the smaller doses be and what should be the interval? Should a maximum dose be built up in a series? Should this series be repeated, and at what intervals? Should the rays be unfiltered or filtered, and to what extent? After fifty years, these problems are not yet solved. Their solution involves the art of the practice of medicine and the specialty of radiology. Much experience, close observation, and accurate detailed records followed by careful analyses by many competent men have, however, carried us far toward their solution. We are indebted not only to the clinical radiologists, but, as suggested above, to the physicists who have co-operated closely with the physicians in their daily work, as Duane, Failla, Friedrich, Fricke, Glasser, Taylor, Weatherwax, and others.

It has been found that the answer to each of these problems varies with the disease to be treated and with its stage and extent. For example, in the treatment of ringworm of the scalp the "epilation dose" should be given accurately at a single sitting, even though a large area is covered. To take another example, in the treatment of plantar warts, two, four, or even six "erythema doses" should be given at once or in two doses with an interval of two days, depending upon the size, duration, and depth of the lesion. In the majority of diseases treated, on the other hand, the full dosage should be divided, as in all inflammations and most malignant neoplasms. For acute inflammations, the dosage should be very small and given at short intervals, while with chronic inflammation, larger doses and longer intervals are indicated.

In the solution of some of these problems, certain "systems" or general methods of treatment have been developed. None of them is as exact and clear-cut in its application as the literature would imply. The authors themselves will be the first to admit this fact. From the very beginning of roentgen therapy, fifty years ago, the dosage was "fractionated" and more or less prolonged. This was necessary because of our lack of measurement and of clinical knowledge. Priority in the use of or development of the so-called "protracted fractional dose method" belongs to no one in particular. It was used by all pioneer roentgen therapists both in Europe and America.

I learned long ago that it is the *total dosage that gives the late degenerative effects—atrophy, telangiectasis, ulceration, and malignant degeneration.* These may occur when there has never been an erythema or noticeable effect at approximately the time of treatment. This is best illustrated by the damaging effect on the hands of the radiologist of prolonged or frequently repeated minute exposures. Therefore, *no matter how small the repeated doses over any*



Saturation Chart I. Chart for unfiltered radiation prepared April 1920, copied from Kingery's work. It will be seen that if a full erythema dose for 100 per cent is given, the estimated retained effect has been reduced to 50 per cent in three and a half days; in seven days, it has been reduced to 25 per cent, and it is estimated to have reached zero on the fourteenth day. When Dr. Kingery found that a full dose could be repeated on any day within these fourteen days, a dosage could be given which would restore the radiation effect in the tissues to 100 per cent, or any portion thereof desired, according to clinical judgment.

length of time, one must reckon with the total dosage. This is illustrated by the damaging effect of repeated small doses used in the treatment of pruritus ani, especially when given by different physicians.

METHODS OR SYSTEMS OF ROENTGEN THERAPY

The first attempt to reduce the "fractional dose method" to a system was made in 1920 by Kingery (31), who introduced "the saturation method," consisting in the delivery of an erythema dose to the diseased tissue and maintenance of this effect for a certain time by means of additional smaller doses to correspond to the loss in effect during any given period. Kingery apparently made only a preliminary report on the method as it applied to skin diseases.

This method and the principles upon which it is based appealed to me, and I immediately adapted these principles and *applied them with higher voltages and filtered radiation in the treatment of deep-seated malignant growths.* After five years I presented the subject before the Internationa Congress on Radiology held in London, i 1925. I have used the method in principl since 1920 and am still convinced of it value. On re-reading my original paper, would make practically no change today except to state that the 100 per cent i built up gradually and the dosage curv can be increased 10 to 15 per cent. If any one is interested in more details, they ar to be found in the article as first presente (44) and in my subsequent observation (45–49).

Kingery said:

"The maintenance of the optimum tissue effect mus necessarily depend on the rate at which the effects o the rays are lost. Depending on this time rate is the frequency with which exposures may be repeated, and the quantity that may be administered at each exposure. It seems but logical to assume that tissues exposed to roentgen rays lose that effect in a constant manner. That the greater the concentration of the biochemical products of irradiation, the higher the velocity of loss, would not only seem to follow naturally, but also apparently is borne out by the observations cited below. If this be true, and if we may assume that the rate of loss varies directly as the concentration of some hypothetical

decomposition product, then as this concentration decreases, the velocity of loss will become less in direct ratio. Thus, at such a time as this concentration has decreased by one-half, the velocity of loss will have become less by a similar amount, and so on until the residual effect has become negligible. This rate of loss, theoretically, would represent a logarithmic curve and may be so calculated. Such a curve has been established for many chemical and biologic reactions, which we know as 'mass reactions' and if we may be permitted to draw an analogy, the biochemical change resulting from the absorption of roentgen rays by tissue elements may follow a similar law.

"Should such an analogy be approached, the decreasing residual effect in exposed tissues might describe such a curve as above suggested, and might well lend itself to such a method of representation and computation. In other words, if our analogy is correct, the curve of residual effect in exposed tissues would be a logarithmic curve, and with the velocity of recovery in logarithmic functions, and the intervals between exposures in days, as units, we should be able mathematically, to estimate fairly definitely the residual effect of the rays in the tissues at any given time, and likewise the dosage required at that time, to return the tissue to the saturation stage."

Kingery conducted his clinical observations on *skin diseases, using unfiltered rays.* In such cases the biological effect is assumed to have decreased to a negligible quantity in fourteen days. According to Kingery's chart (Saturation Chart No. I), based on the clinical observation that a 100 per cent dose could be repeated in fourteen days, it may be seen that, at the expiration of three and a half days, the residual effect has been reduced to 50 per cent. After a lapse of another similar period, a total of seven days, it has been reduced to 25 per cent. At each of these points, respectively, a 50 per cent or 75 per cent dose will bring the biological effect to 100 per cent, or the saturation point. With the use of this type of rays for superficial effect, the daily administration of a 25 per cent dose leads, in the course of six days, to 105 per cent and, if further continued, would lead to an overdose. Kingery says: "If, however, only 10 per cent is given daily, the curve does not rise above 60 per cent and one never reaches the optimum or maximum dose."

I commented as follows:

"It must not be assumed, from this latter statement by Kingery, that such small doses can be kept up indefinitely or even that the saturation process can be continued indefinitely or very long. This is the great danger from the method. One must always keep in mind the atrophy, endarteritis, and late degenerative processes, or even early necrosis, which are likely to follow total over-dosage. On the other hand, if the radiation is kept at the saturation point (or as nearly so as the normal tissues will permit) during the brief period of sensitivity of the malignant cells, and while these cells are still undergoing division, it is likely that the disease can be more completely destroyed. At least, this is my opinion."

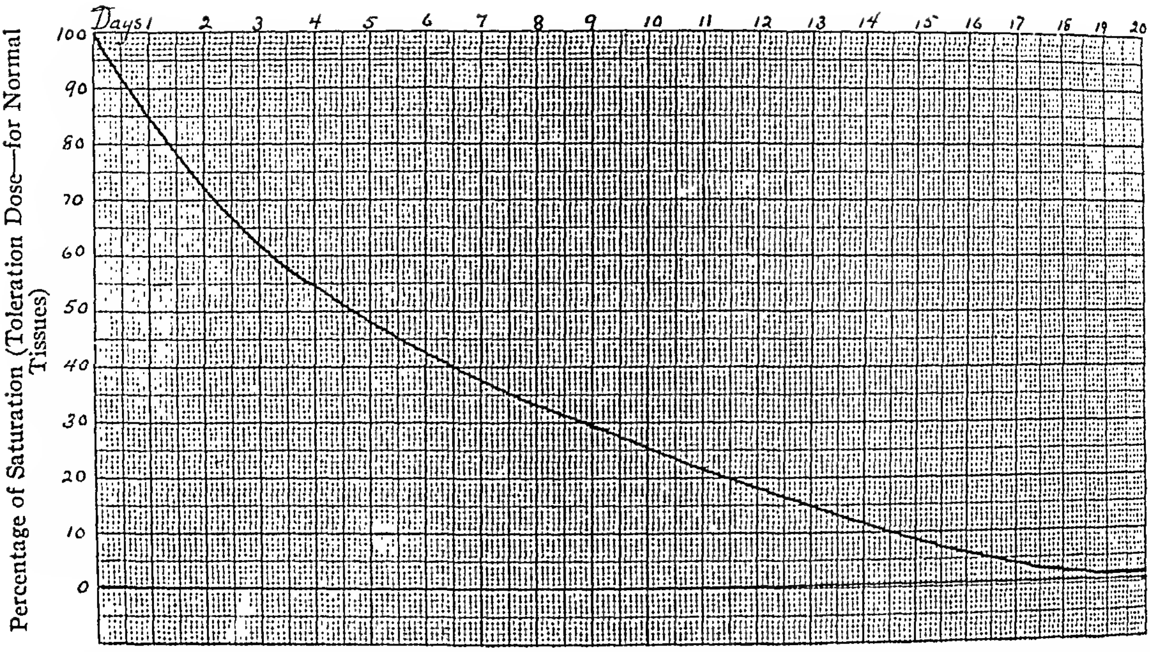
In 1925, I commented further:

"In my work, we have been using this saturation method cautiously more or less during the past five years, giving it up only from time to time while we were trying out the single massive dose methods, which I have now given up excepting where the disease is strictly localized and can be safely overdosed."

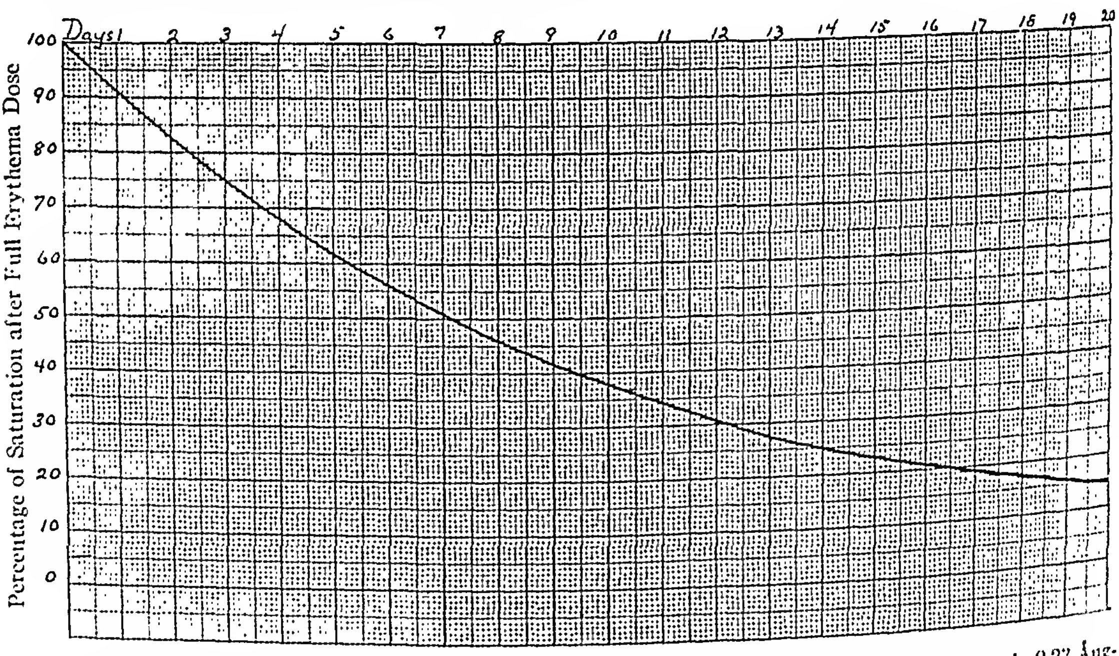
By "saturation" we mean the limit of skin or normal tissue toleration. The saturation curve must, of course, be varied according to the character of radiation used. On the basis of the Kingery principles, I prepared the curves reproduced in Charts II, III, and IV, for use with filtered radiation and higher voltages in the treatment of deep-seated malignant lesions. One must, of course, take into account not only the "saturation" effect on the skin but the dose in the deeper tissue—"the tissue dose" or the "tumor dose," which is usually obtained by cross-firing.

The *massive dose technic* was advocated by L. Seitz and H. Wintz (62) in 1920. By this method, the full "erythema dose," "carcinoma dose," "sarcoma dose," is administered in the shortest possible time. These authors and others in Germany reported remarkably good results from this method, especially in uterine disease, but the technic never became popular in America and the term is now rarely used.

Regaud (55), of Paris, studied the influence of radiation upon cells during the process of division and, about 1914, suggested a technic in which the treatment by comparatively small intensities is extended over a very long period, so that more neoplastic cells are exposed to irradiation during the phases of mitosis, when they are most sensitive to the destructive effects of radiation. This method of using roentgen rays gives a prolonged effect somewhat



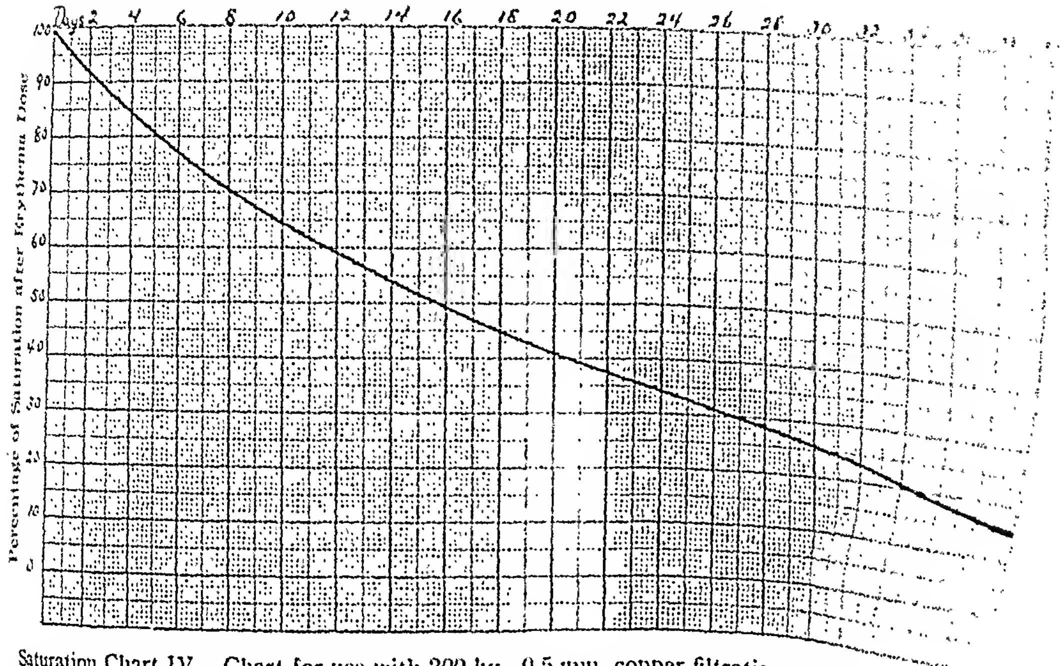
Saturation Chart II. Chart prepared for use with a 9-inch spark-gap (127 kv., 2 mm. aluminum filter). I had observed clinically that I could repeat an erythema dose with such technic in three weeks. I therefore adapted the principles described by Kingery, so that 50 per cent could be added at the end of five days, and 75 per cent could be added in approximately ten days, etc.



Saturation Chart III. Chart for use with 170 kv., 6 mm. aluminum filtration (= approximately 0.23 Ångström mean wave length). With this type of radiation I had learned clinically that I could repeat a full erythema dose in four weeks, and the chart follows the principles illustrated above, allowing a repetition of 50 per cent of an erythema dose in one week, or one-fourth of the former interval, etc.

similar to that obtained with radium, but the roentgen rays have an advantage in that they give a greater depth intensity, due to the greater focal skin distance. This is in accordance with the inverse-square law in the physics of light.

About 1920, Henri Coutard, who was associated with Regaud in the Curie Radium Institute, applied these same principles, with detailed modifications, to the treatment of epithelioma, especially about the face, neck, pharynx, and larynx. His su-



Saturation Chart IV. Chart for use with 200 kv., 0.5 mm. copper filtration, and 2 approximately 0.165 Ångström units mean wave length, prepared May 8, 1923. I lear ence that with this type of irradiation, I could repeat 100 per cent of an erythema dose fore, following the above principles, a 50 per cent dose could be repeated in one-fourth th etc.

erior results, particularly in the treatment f carcinoma of the larynx, attracted much ttention to this method, which is now ommonly referred to as the "Coutard echnic." The "Coutard technic" is not firmly set pattern or established rule. outard has himself always adapted the ethod to the individual case. It is erefore very variable, but certain prin- ples, as those established by Regaud, are llowed.

Coutard's method as applied in the eatment of carcinoma of the pharynx, rynx, and tonsils consists, in general, of radiating the area daily or twice daily rough one or more fields, with small in- vidual doses, heavy filtration, and high ltage (originally 200 kv.; now 400 kv.), e dose being "diluted" by increasing the ltration, decreasing the milliamperage, d increasing the distance until, at times, e or two hours or more are necessary to ve 150–180 r, and more recently to give r for special effect. The treatment lasts ree to six weeks and becomes very stly, but it permits a high total dosage d gives an increasing effect on the disease ith relatively less effect on the normal

tissue. It is a more sc with more exact measur observation, of the pro dose method which wa rately by the earliest wo arguments there may method, we must all a ively improved results others who have follow obtained. Schinz, (60), has made a ca results obtained by period of seventeen

The clinical dos gradually solved bu the progressive dev more powerful and as are now being p age roentgen equi invented by E. University of Ca developed by D.

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moment. The literature involves many volumes—both books and periodicals—in all languages. Even a brief record of the contributions would reach encyclopedic proportions. Reference has already been made to Portmann's review of the earlier work (50).

It has been stated that more than 400 diseases have been benefited in variable degrees by roentgen therapy. Skin diseases and malignant growth in all its varieties have probably been the most important fields. Gocht (18) in Germany, was among the first to employ radiotherapy (1897) in the treatment of cancer of the breast. In this country, the first publications on the treatment of cancer were by Johnson and Merrill (24) and by Hopkins (22) in 1900 and 1901. My own experience began in 1901 (41) and was reported before the first scientific meeting of the American Roentgen Ray Society at Buffalo, Sept. 11, 1901. Treatment had been begun Feb. 12, 1901, and I regret to say without any knowledge of the prior reports mentioned above. Early roentgenologists who did much to establish roentgen therapy in this country include Pusey (51–53), Leonard (34), Pancoast (39), Beck (2), and others. These men and their contemporaries throughout the civilized world labored under tremendous difficulties—lack of knowledge, inadequate equipment, and serious danger (see Figs. 4 and 5).

The results obtained during the past fifty years in the roentgen therapy of both superficial and deep-seated disease form the basis for a hope of even greater accomplishment in the future, as we acquire improved equipment, greater knowledge of the nature of disease and of the biological effects of the rays, and increased skill in their application to the individual patient. To repeat: *Knowledge and skill in the use of this instrumentality are as important as knowledge and skill in the use of the instruments in surgery and more difficult of attainment because the immediate effects cannot be seen.*

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Roentgen Radiations in Biological Research

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THE PURPOSE of this paper is to recount briefly the work of those biologists who first studied the effect of roentgen rays on living cells, and to show how the results that they obtained, often under great difficulties, have provided the basis of subsequent investigation. Progress in this field has not been steady. During the first dozen years after Röntgen's discovery, the pioneers carried on exploratory work and saw clearly the fundamental problems which should be solved. But in the next dozen years interest in x-ray research waned, although radiotherapy was advancing rapidly. Biologists turned their attention to radium radiations and with their use made important contributions, especially to experimental embryology. Early in the third decade of the present century x-rays again began to be used in biological research and have been increasingly employed ever since. The literature is now extensive. In this review it is possible to cite only a few examples of research in some of the fields of investigation.

THE EARLY INVESTIGATORS

Those who first tested the biological effect of x-rays on small organisms were interested in determining whether they could be used as a bactericidal agent. Handicapped by the low intensity of the beams produced by the static machines then in use, and by the fact that bacteria are relatively resistant, they were unable to find any effect at all. In 1898, however, Rieder (59) demonstrated that growth could be somewhat inhibited. Biologists then turned their attention to plant cells and to *Protozoa*, whose reactions could be more easily observed. Lopriore in 1897 (46) noted that the circulation of the protoplasm in the cells of certain water plants was accelerated after a moderate exposure to x-rays and that it returned to a normal rate in a short time. A longer exposure terminated in the coagulation of the protoplasm, an observation confirmed a little later by Schaudinn (63), and more recently by others who have used, also, gamma rays and the ultraviolet. The retarding action of the rays on cell division was noted by Koernicke (40), who observed that, if the exposure was not too severe, normal growth might be resumed; the injured cells were capable of recovery. He also demonstrated that seeds exposed after they had taken up water and had started to germinate were more sensitive than dry seeds. In this connection, the observation of Schaudinn is of interest. He found that there was a wide difference in sensitivity among different kinds of *Protozoa*, and that those with highly fluid protoplasm were more susceptible than those with less fluid protoplasm. Thus the physiological condition of the cells at the time of exposure was shown to be a factor in determining sensitivity.

At this time it began to be suspected that x-rays might be the cause of the sterility developing in clinical radiologists. That such was indeed the case was demonstrated by Albers-Schönberg (1) on guinea-pigs and rabbits. When either the male or female was irradiated, no litter was produced. The histologic changes in the irradiated testes were studied the next year by Bergonié and Tribondeau (7), who found that the seminiferous tubules of the rat may be severely injured with the result that spermatogenesis stops completely. The chromatin of the spermatocytes proved to be highly susceptible, but the Sertoli cells remained uninjured. This condition was not permanent, for after some weeks the epithelium regenerated.

That dividing cells are highly susceptible to x-rays was shown by Perthes (55) in his experiments on *Ascaris* eggs. He

concluded that mitosis is the stage of least resistance, but that the eggs could be injured even when exposed during the resting stage. This he proved by keeping them in an atmosphere of hydrogen for some weeks, during which time cell division ceased. On irradiating them, he found that abnormalities developed, although not to so great an extent as when the eggs were exposed during actual cleavage. Regaud and Blanc (58) confirmed these findings and added that the chromatin is the most sensitive part of the cell. It was their belief that the physical and chemical condition of the chromatin is more important in determining sensitivity than the physiological condition of the cell at the time of irradiation. Krause and Ziegler (42) did not agree with this view. In their opinion, sensitivity depends more on the stage of mitosis during which irradiation is carried out than on the kind of cell.

In 1906, Bergonié and Tribondeau (8) summed up the results of their own extensive investigations and those of others on the problem of sensitivity in the following statement: X-rays act with greatest effect on cells whose reproductive capacity is high; on cells whose development involves mitotic divisions (they referred particularly to spermatocytes); and on cells whose morphology and functions are not definitely fixed. These generalizations are true in the majority of cases, but exceptions were pointed out at once. Thus it was shown that bacteria and yeast, although they divide rapidly and continuously, are highly resistant, while some tumors which grow slowly are sensitive.

The effect of x-rays on the course of embryonic development was studied by Gilman and Baetjer (26), who described the various abnormalities appearing in the larvae of *Amblystoma* following exposure of the fertilized eggs. A few experiments on the developing chick indicated that the nervous system was especially susceptible. In the same year, Perthes (55) followed the abnormal development of irradiated *Ascaris* eggs, showing how the chromosomes are injured and behave eccentrically on the mitotic spindle. Similar observations were made on plant cells by Koernicke (40), who used radium radiations. At this time, also, Bardeen and Baetjer (6) noted that x-rays inhibit the process of regeneration in *Planaria*. A little later Bardeen (5), apparently the first to use the rays as a tool of research, fertilized normal toad eggs with irradiated sperm and described the abnormalities which appeared at the time of hatching. In his opinion, the damage produced by the rays could be explained on the assumption that the nuclei were injured and rendered incapable of exerting their normal influence on cell metabolism.

The year 1904 marked the publication of many important contributions to the subject of the biological effects of x-rays. To those already cited should be added the prophetic remarks of the eminent botanist and evolutionist, Hugo DeVries (23): "The rays discovered by Roentgen and the radioactivity of the new element radium have already proved themselves capable of provoking important changes in living organisms. These changes are partly of a retarding nature, and some processes are more sensitive than others. If the same holds good for our dormant representatives in the egg [he refers to hereditary factors] we may hope some day to apply the physiological activity of the rays of Roentgen and Curie to experimental morphology."

Thus in the first dozen years following Röntgen's discovery the foundations of future radiological research were firmly laid. The problems of sensitivity and recovery, of chromosomal abnormalities, of inhibited growth and regeneration, were explored in a preliminary way, and the use of the rays in genetic studies was foretold. But on these foundations very little was built for a long time. War interrupted research, especially in Europe, and it was not until 1922 that an important step forward was taken in the field of radiobiology. From that time until the present, research has been active and rewarding.

X-rays have proved to be a useful tool in

biological research because with appropriate doses the experimenter can produce a wide variety of effects, ranging from reversible reactions, such as a retard in the growth rate or a change in the viscosity of the protoplasm, to irreversible reactions and ultimate death; from minute changes in a single chromosome, which result in alterations in the hereditary material, to a complete breakdown of all cell constituents. Between the smallest dose which produces a recognizable effect and a full lethal dose for the same kind of cell, the difference is great, whereas for other agencies, such as temperature or chemicals, it is comparatively small. Thus 50 r will cause a definite but temporary decrease in the rate of mitosis in tissue-culture cells; a dose of 750 r permanently reduces their rate of growth, while more than 13,000 r must be given to cause a delayed lethal action in all of the cells. It is because of these wide variations in the dose that may be applied within the physiological limits of the cell, and because of great differences in sensitivity, that "it is possible by the use of radiations to destroy certain types of cells, as though by a surgical operation of surpassing delicacy. We can also reach within the cell and effect changes, particularly in the nucleus" (19).

The most obvious effect of x-rays on growing cells and tissues is a retard in the division rate. This may be seen at once in tissue cultures, in which a dose of 240 r produces an immediate drop in the number of mitoses (69). Those cells which have already begun to divide complete the process, but those in the resting stage remain in that condition for some time. Later, if the dose has not been too severe, they resume their mitotic activity.

The retard in the growth rate of seedlings was first employed as a measure of dosage as early as 1915 (60) and has since been extensively used for this purpose. The conclusions drawn by many who adopted this method were faulty, chiefly because too few specimens were used. But with appropriate methods and sufficient numbers, significant results may be obtained. Henshaw (33) has used t amount of retard as a measure of sen tivity of seeds and seedlings at differe stages of development and under vario external conditions.

After light doses the retard is tempora and may be followed for a short time by growth rate even faster than that of t controls. This response was long consi ered to be due to a direct stimulati action of the radiations (38, 41). It w assumed, without adequate support, th human tissue cells respond in the same wa and the term "stimulating dose" came be used among therapists. But those w have employed large numbers of seeds a seedlings, in which the effect can be mo easily detected, have failed to find eviden of real acceleration. There is no increa in germination, or increase of vegetati parts which results in greater dry weig An extensive summary of this topic h been made by Johnson (37).

After heavy doses the growth of se lings and embryos continues for some ti but the organisms sooner or later die af developing into bizarre forms. Knuds (39), however, found that fern spor after a dose of 50,000 r, lived and grew, though they did not germinate, and t some individuals remained alive a healthy for as long as eighteen mont The ability of adult cells to survive e greater doses is remarkable. The isola frog heart after receiving 100,000 r ma tains its normal rate and amplitude of c traction (64).

The response of protoplasm, first scribed by Lopriore, has already been m tioned. By means of motion pictu other reactions of living cells can be se Canti (13), who used beta and gamma r of radium, demonstrated that movem in wandering tissue-culture cells quic ceased, the cells rounded up, then l their smooth outlines, and finally disin grated. Under the intense radiation e ployed, cells in actual division were una to complete the process. Vollmar (found that a dose of 1,900 r of x-rays, livered at the low rate of 16 r per minu

produced about the same results. The cell wall appears to be especially vulnerable, for frequently the cell bursts, allowing the protoplasm to escape. Tumor cells he found more sensitive than normal cells. In them he noted the formation of vacuoles, a response which follows the application of many injurious agents and is associated with the phenomenon of coagulation.

A theory to explain the reaction of cells to radiations was proposed in 1913 by Bordier (11), who noted that proteins irradiated *in vitro* lost their solubility and were precipitated in the form of fine granules. This denaturing effect would account, he believed, for all the observed cellular reactions. The doses he used to produce this effect were, however, far greater than those which injure living cells. Wels and Thiele (73), using a dark-field ultramicroscope, observed the denaturing reaction after much smaller doses than those used by Bordier, but still of considerable magnitude. Wels (72) claims that it can be seen in living cells, but the evidence is not convincing. Should the denaturation occur after small doses, cells would undoubtedly be injured because of the loss of affinity of their proteins for water; but it is by no means certain that it does occur under these conditions.

Heilbrunn (29) has proposed the theory that radiations release bound calcium from the cell cortex, a reaction which results first in the liquefaction of that structure, and probably an increase in its permeability. At the same time there is a general weakening of the cell membrane, as a result of which the cell may rupture. The free calcium ions enter the protoplasm, causing first a liquefaction and then coagulation, accompanied by the production of numerous vacuoles. "Thus we have a mechanism of extreme delicacy, one that can account for the radical colloidal changes observed, without recourse either to the insensitive process of ordinary coagulation or to a purely hypothetical mechanism such as special enzyme effects or point heat effects. This reaction accounts for (though it does not explain) the morphological concomitants of radiation effects, and for the fact that the stimulating and injurious effects of the rays in protoplasm are essentially the same as the effects of other effective physical and chemical agents."

An analysis of some phases of the fertilization process can be made with the aid of radiations, for the nuclei of the gametes can be injured in varying degrees without preventing the cleavage of the egg. In this way information is obtained on the role played by the cytoplasmic portion of the sperm and egg. Following Bardeen's early work, the Hertwigs (35) made an extensive study of the action of radium radiations on both sperm and eggs, and discovered that the greater the dose given to either gamete prior to insemination, the more regular was the course of development. This paradox they explained on the assumption that a moderately injured sperm nucleus attempts to fuse with the normal egg nucleus but, in so doing, interferes with the process of cleavage. After heavy irradiation it initiates development but takes no part in the cleavage process, which is therefore haploid. So also the irradiated egg, after fertilization with normal sperm, divides under the influence of the sperm nucleus, the egg nucleus playing no part in the process.

Simon (65) repeated and amplified this experiment, using x-rays, gamma rays, and ultraviolet rays on frog eggs and sperm. With ultraviolet, the Hertwig paradox was evident, but after treatment with x-rays or gamma rays it appeared only occasionally. Dalcq (22) made a cytological study of this material and found that embryos developing after the ultraviolet treatment had a haploid constitution, as Hertwig postulated, but that those developing after treatment with the shorter radiations, although frequently haploid, were nevertheless abnormal.

That the doses used were too small was shown by Rugh (61), who found that, when irradiated frog sperm is added to normal eggs, the number of embryos that hatch decreases to practically zero as the

increase from 15 r to 1,000 r. But with doses greater than 1,000 r there is a rising curve of hatching percentages, which may reach 90 per cent at 50,000 r. These embryos probably have a haploid constitution. Later Rugh and Exner (62) modified the experiment by using bullfrog sperm and leopard frog eggs. Under normal conditions, fertilization occurs but development goes no further than the gastrula stage. There is an incompatibility between the two gametes. With increasing doses applied to the sperm, more and more eggs develop beyond gastrulation, until after a dose of 66,000 r, 80 per cent of the embryos hatch and develop into tadpoles.

It appears, therefore, that by sufficient radiation the incompatible substance in the bullfrog sperm can be destroyed; development is thus a kind of artificial parthenogenesis. According to Rugh, the eggs inseminated with irradiated sperm show a normal cleavage pattern and cleavage rate. But Henshaw (31) reports that sea urchin eggs inseminated with irradiated sea urchin sperm divide more slowly than normal. He believes that the delay "varies with the rate at which some sensitive substrate is being changed or destroyed by the radiation." It is by such experiments as these that the factors involved in the fertilization process can be analyzed.

Changes induced by x-rays in chromosomes have been studied since Perthes (55) first described their swollen shapes and abnormal behavior. Since that time details of the irregular distribution, the formation of multinucleate cells, the occurrence of two or more mitotic spindles, and other reactions have been fully described. Some obvious abnormalities are of special interest from the genetic point of view. "The smaller, less conspicuous and often viable chromosome alterations which have proved to be most valuable and significant cytogenetically, were almost completely overlooked" (28). Three general types can now be distinguished. Chromosomes may become sticky and clump together (2) and, when separating, may spin out chromatin bridges; excessive clumping prevents the completion of mitosis. A second effect is the breaking of chromosomes, either temporarily or permanently; a third effect is the gene mutation, which obviously is not visible.

The sticky quality may be due to a change in the nucleic acid which forms a coat around the chromosomes when they condense preparatory to division (14). This condition was apparently the cause of the genetic results obtained by Mavor (47), who was the first to find hereditary changes in x-rayed *Drosophila*. In his experiments Mavor crossed irradiated females having a dominant character with recessive males. Normally all the progeny should show the dominant character, but he found a number of males which resembled the fathers. This result had been found occasionally in the offspring of non-irradiated parents and is due to the fact that the X chromosomes of the female, instead of separating during the maturation process, remain together. As a result, one daughter cell receives two, and the other none. Radiation increases the frequency of this phenomenon, known as [illegible] junction, by about twenty time[illegible] because the increased stickin[illegible] chromosomes prevents their [illegible] Subsequent tests have sho[illegible] crease is proportional to [illegible]

The second effect pr[illegible] consists in the breaki[illegible] This may be caused by [illegible] gether in certain pla[illegible] quent pulling apart un[illegible] the spindle fibers. Th[illegible] re-attached to the [illegible] their original orien[illegible] position; or they m[illegible] ends of other chro[illegible] priate breeding ex[illegible] to determine preci[illegible] have been involved [illegible] what manner re-at[illegible] how much may ha[illegible] It is beyond the sc[illegible] sent the genetic [illegible] conclusions. They [illegible]

gether with cytological proof of the alterations, by Dobzhansky (24).

The possibility of obtaining gene mutations by the application of radiations, hinted at by DeVries, was explored by a number of investigators, but for some years without success. Morgan and his collaborators tried radium rays on *Drosophila* (50) but were not satisfied that their results were significant. Little and Bagg (45) exposed mice to x-rays and obtained an undoubted mutation, but repetitions of the experiment were not successful. It was not until 1927 that Muller (51), who had long studied spontaneous mutations in *Drosophila*, and had developed elegant methods for their quantitative study, succeeded in obtaining positive evidence that x-rays greatly increase the mutation rate. At the same time Stadler (67) found mutations in irradiated corn and barley, and Goodspeed and Olson (27) in tobacco.

Since that time numerous investigations, in which both animals and plants have been used, have demonstrated that the number of mutations produced by radiations is proportional to the amount of energy absorbed. This is true whether doses of high intensity are used, or divided doses of low intensity are applied over a long period. The mutation is apparently a change in the gene, and is not reversible, that is, a return to the original condition does not normally occur. But subsequent irradiation may occasionally cause a reverse mutation.

The production of these effects is not dependent on the wave length of the beam. The same dose, measured in roentgens, produces the same quantitative effect whether 10-kv. x-rays are used, or highly filtered gamma rays. The rate of mutation is not influenced by the temperature at the time of exposure. Whether the genetic change is brought about by a single quantum hit, or by a chain of events initiated by quantum hits, is the subject of lively debate.

X-rays thus furnish genetics with an invaluable means of studying mutations and chromosomal aberrations of various kinds because they greatly increase the number of such phenomena over that found in nature. These changes in the hereditary material are apparently the same as those that arise spontaneously. The significance of this fact has been commented on by Muller (52), who has made many notable contributions to genetic research. "If spontaneous mutations serve as a basis for evolution (no other basis has been found), then artificially produced mutations likewise must include amongst them artificial building blocks of evolution as good as the natural stones."

THE SENSITIVITY PROBLEM

Differences in sensitivity to radiations among different kinds of cells, in cells at different periods of the life cycle of the organism, and at various stages of mitosis, attracted the attention of the first radiobiologists. Much information on this topic has since been obtained, and theories to explain the phenomenon have been proposed, yet little progress has been made toward the solution of the problem.

That sensitivity changes rapidly during mitosis is clearly demonstrated, but there is little agreement on what stage is the most susceptible. Holthusen (36) concluded that in *Ascaris* eggs the metaphase is the most vulnerable period. This is also the opinion of Whiting (74), who has made extensive experiments with the eggs of the parasitic wasp *Habrobracon*. The difference in sensitivity between the prophase and the metaphase of the first maturation division is truly great. Exposed during the former period, half of the eggs fail to hatch after a dose of 11,800 r; exposed during the metaphase, 450 r suffice to produce the same result. Thus the latter stage is about thirty times as sensitive as the former. Vintemberger (70) states that in the frog egg, sensitivity is low at the prophase and rises until the telophase is reached. The latter is about six times as susceptible as the prophase. Opposed to these views is the opinion that the prophase is the most sensitive stage (69), and that the metaphase is the least susceptible period (43).

During development there is a progressive loss of sensitivity. A single example will suffice to illustrate this point. The eggs of *Drosophila* grow more susceptible from the time they are laid until cleavage ceases, a period of about two hours (54). Thereafter they rapidly become less susceptible, except at the time of gastrulation, a critical period in the development of all kinds of eggs. The median lethal dose for young eggs is 190 r; for the young larva, 1,300 r; for the adult fly about 100,000 r. Woskressensky (75) has presented accurate data which show that the decrease in sensitivity with age is synchronous with a decrease in growth velocity. It is possible to predict the time of death of an irradiated embryo if the dose and the age of the individual at the time of exposure are known. By increasing the normal growth rate, sensitivity should also be increased. Experiments with developing *Ascaris* eggs (36) and *Drosophila* eggs (53) show that this is indeed true. The rise in susceptibility, however, is comparatively small, while the increase in the rate of cell division is large in comparison. The two phenomena are not parallel, indicating that other factors than these are operating.

The generalization of Bergonié and Tribondeau that the sensitivity of cells varies directly with their reproductive capacity and inversely with their degree of differentiation is, with important exceptions, true. This is seen in the results of experiments on regeneration. The early work of Bardeen and Baetjer (6) on fresh-water planarians showed that after exposure to x-rays no new tissue was produced, nor were lost parts restored. The specialized cells of the digestive, muscular, and nervous systems were not injured, but the unspecialized or formative cells which take part in the process of regeneration had lost their power to divide. This was true also of the reproductive cells. More than twenty years later Curtis and his colleagues (20) also using *Planaria*, a favorite form for studies in regeneration, demonstrated that there is a direct relation between the number of formative cells remaining alive after irradiation and the amount of regene tion which ensues. Thus, by taking vantage of the highly susceptible natur these undifferentiated cells, he was abl show that they are directly concerned the process of regeneration. The effec irradiation appears soon after exposi while the differentiated tissue cells are visibly altered.

The experiments of Butler and his leagues (12) on regeneration in amphib larvae also demonstrate that undiffe tiated cells are highly susceptible. W a larval limb is amputated, the cells in proximity of the cut surface underg process of dedifferentiation and form a or blastema over it. From this structu tissues to replace the lost parts are forr by the differentiation of cells composing If the blastema is irradiated, its power differentiate is suppressed, and no reg eration follows. Indeed, the cells in amputated stump of the limb unde dedifferentiation and the limb finally appears. But the larva as a whole is affected by the doses used. Thus it appe that cells normally somewhat resist quickly become susceptible when they l their normal characters and assume a differentiated condition.

It has long been realized that the sei tivity of cells and organisms can be creased or decreased by changing th environmental conditions, particularly temperature and the state of hydrati The interpretation of the results is easy. Each change affects vital proces in different degre he sum of the vario changes is wh which make lyzed.

Variou while ch lower t tivity i other a such co (3) res when their Maxw

grains at the temperature of liquid air (−187° C.) and found that, while many were injured, their subsequent growth exceeded that of the specimens irradiated at room temperature. They conclude that the death of the grains which succumbed to the treatment is not primarily due to temperature-dependent thermochemical reactions occurring at the time of exposure, but that factors which produce delayed death are diminished by extreme cold.

The effect of x-rays on a warm-blooded animal chilled during exposure has been studied by Evans and his associates (25), who irradiated rats at temperatures ranging from 37° to 0° C. In all cases the dose was 2,010 r. At the lowest temperature no effect on the skin could be seen; at 17° C. there was a slight epilation, while at 37° C. epilation was complete. The authors believe that lowered metabolism during exposure may be the controlling factor in determining sensitivity.

The experiments with the rat skin and the corn grains are comparable, for in each case the temperature used was the minimum which could be withstood for a short time. But the other seeds and the eggs mentioned above may be frozen for long periods without injury. The fact that this relatively moderate degree of cold has no effect may not be significant, but organisms exposed while chilled to the lowest temperature at which they can survive are less sensitive than they are at their normal temperatures.

When cells are irradiated and then chilled for varying periods, the apparent effectiveness of the rays is diminished; a larger proportion survives than in samples kept at normal temperatures. Holthusen (36) showed this to be true for *Ascaris* eggs. Samples incubated at 22° C. after exposure showed about two and one-half times as many abnormal forms as were found in samples incubated at 2° C. More recently Cook (16) reported that, when these eggs, having received 5,000 r, are kept at 25° C., 1 or 2 per cent develop normally; but if kept at 5° C., 45 per cent are normal. Tissue culture cells respond in much the same way. Strangeways and Fell (68) found that irradiated cultures of six-day chick embryos survive if incubated at 5° C. but die when kept at normal incubation temperatures. These results are interpreted to mean that when cell division and metabolism are at a minimum, cells can partially recover from their injury.

The early observation of Koernicke that seeds show increased sensitivity to radiations after taking up water has been followed by a few attempts to determine more precisely the relation between water content, cell activities, and susceptibility. Petry (56) concluded that sensitivity in seedlings is a function of the degree of hydration. In the presence of water, chemical transformations are induced and these lead to injury. Henshaw and Francis (34) have measured the rate at which water is absorbed by wheat seeds, the rate of oxygen consumption, and the changes in sensitivity during early growth. In the first six hours, water is absorbed rapidly but sensitivity remains almost unchanged. Subsequently the rate of water intake is reduced, while sensitivity shows a notable increase. This occurs before cell division commences. During the entire period the rate of oxygen consumption rises steadily. In the reverse experiment, seedlings were dried and then irradiated. The result was a definite decrease in sensitivity. The authors conclude that no quantitative relation exists between susceptibility and water absorption, oxygen consumption, and mitosis, but that sensitivity rises when water is absorbed and growth commences.

PHYSIOLOGICAL RESPONSES

The way in which x-rays produce their effects has been the subject of much speculation and a considerable amount of research. It is generally agreed that the primary effect is an ionization which tends to transform complex molecules into simpler compounds. Under ordinary conditions of exposure the amount of chemical change is small, but chain reactions may be set up which ultimately affect the entire cell. It is possible, for example, that

some enzymes are inhibited or destroyed, with the result that normal metabolic processes are deranged. These secondary reactions are followed by the appearance of visible alterations. The latter give no clue to the nature of the preceding processes; indeed, they are practically identical with the effects produced by other injurious agents whose mode of action is wholly unlike that of radiations.

It is apparent that x-rays have little or no effect on the rate of oxygen consumption. Bersa (9), who reviewed the literature published up to 1927, stated that no decrease in the respiratory rate of seedlings could be detected until abnormalities in growth appeared. The same result was obtained by Chesley (15) on seedlings and on marine eggs; and by Boell (10) on grasshopper eggs. The fact that growth is impaired before the rate of oxygen consumption is altered makes unlikely any action of x-rays on respiratory catalysts.

The effect of x-rays on glycolysis has frequently been studied, with contradictory results. Scott (64), who reviews the literature on this topic, concludes that this process is not affected, but Crabtree and Gray (17) find that when the rat retina is given no more than 1,000 r, the formation of lactic acid from carbohydrate is checked within a few minutes, although respiration is not affected.

The opinion has prevailed that, in general, enzymes are highly resistant. However, Dale (21) shows that the apparent lack of sensitivity may be due to the experimental conditions usually followed. He finds that 50 r inactivates about 30 per cent of a dilute solution of carboxypeptidase, but when the concentration of the solution is increased 345 times, 100,000 r must be given to accomplish the same result. If concentrations are of the same order as those occurring in living tissues, many catalysts may be affected by comparatively small doses. There can be no doubt that further investigation with appropriate technics will show that the inhibiting action of x-rays on these substances is an important factor in producing the observed alterations in cells.

The fact that during stages of high sensitivity, chromosomes have a high content of nucleic acid, while during stages of resistance they have about half as much, leads Sparrow (66) to conclude that susceptibility can be correlated with nucleic acid metabolism. This is also the view of Mitchell (49), who reviews the literature on the effect of radiations on metabolic processes. About forty years ago Bardeen came to a somewhat similar conclusion: "An injury to the nuclei of cells sufficient to destroy the normal influence on metabolism would suffice to account for all phenomena which have been observed."

RECOVERY

The ability of an organism to recover wholly or in part from x-ray injuries was noticed by Koernicke in 1904, and since that time many examples of recovery in tissue-culture cells and in developing organisms have been described. It is generally assumed that, when the x-ray intensity is low, the rate of repair is sufficient to balance the rate of injury. Thus a dose of 190 r delivered to *Drosophila* eggs at the rate of 5 r/min. or more kills ha[illegible] dividuals in the sample. But [illegible] sity is reduced to 2 or 3 r/[illegible] kills only a small prop[illegible] covery rate is therefore [illegible] rate of injury produced [illegible] sities. At the other [illegible] zoan *Colpidium*, w[illegible] affected unless the [illegible] 800 r/min. (18). [illegible] covery rate is hig[illegible]

Clinical meth[illegible] that self-repair [illegible] ties are used [illegible] only within re[illegible] been made to [illegible] proof of the [illegible] (30) measured [illegible] *bacia* eggs [illegible] When the u[illegible] and fertiliz[illegible]

division is delayed, the amount of delay increasing with the dose. This is an obvious sign of injury. If now the irradiated eggs are not fertilized at once but only after intervals ranging from 10 to 220 minutes after the end of the exposure period, the delay in the onset of cleavage is lessened, an indication of partial recovery. The delay is an approximately exponential function of the time interval between the end of exposure and the moment of fertilization. In another investigation, Henshaw found (32) by studying the larvae developing from eggs treated in this way, that the period of recovery is apparently limited to the interval between exposure and fertilization, that is, to a quiescent period.

Quimby and MacComb (57) use a different approach for estimating the amount of recovery in the human skin. The dose needed to produce a definite reaction after two exposures separated by various time intervals is larger than the single dose which will give the same reaction. The difference represents the magnitude of the dose from which the tissue has recovered during the interval. In the first twenty-four hours they find a 67 per cent recovery rate; for the second like period, 31 per cent. Unlike the recovery rate found for *Arbacia* eggs, that of the human skin cannot be expressed by a simple exponential curve.

The conditions in which recovery can occur have received little attention. In view of the experiments already mentioned, in which irradiated cells and organisms were chilled after exposure, the conclusion may be drawn that recovery occurs when mitotic activity is at a minimum. Lea (44), in presenting a theory of action of radiations on biological materials capable of recovery, cites the observation that tissue-culture cells exposed shortly before they are due to divide exhibit a delay in cell division, while those exposed some hours before their normal time of mitosis do not. He remarks that "it is probably safe to say that a given dose of radiation produces the same physical and chemical changes in a cell due to divide an hour hence, as in one due to divide five hours hence, yet on account of the times available for recovery being different, the one cell finds itself unable to commence division at the proper time, while the other cell enters mitosis entirely according to programme."

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1895 1945

Modern Physics and the Discovery of X-Rays

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Among the most striking practical developments resulting from the discoveries of modern physics are radio and the atomic bomb. Both are fruits of the discovery of x-rays. In our effort to understand the nature of the world around us, prominent recent advances include knowledge of the arrangement of atoms in crystals and molecules, recognition of the several elemental particles of which atoms are built, the electron and the nucleus, the proton and the neutron, the positron, the mesotrons, and so on, and something of the way in which these particles combine to form atoms. We have learned in the theory of relativity the laws of motion of stars and atoms moving at very high speeds and more precise laws of gravitation. In the quantum theory we have greatly improved our understanding of the nature of light and x-rays and have learned how to describe the motions of atoms and the parts of atoms. All of these new findings stem from Röntgen's discovery of x-rays fifty years ago, and in their development x-rays themselves have been used as a vitally important tool.

We might point out, also, how chemistry, geology, biology, and philosophy have been enriched by Röntgen's discovery. We could show how the electronic tools have stimulated the growth of industry, how the electron tube has made possible not only the radio but also the long-distance telephone and greatly improved telegraphic communication. We could describe the use of x-radiation and radium in the diagnosis and treatment of diseases. All of these have come from the discovery and use of x-rays. They are, however, part of a larger story that we cannot here take time to tell.

Two years before the discovery of x-rays, in his statement of the purpose for which the new Ryerson Physical Laboratory of the University of Chicago was built, Professor A. A. Michelson noted that the fundamental principles of physics had been well established. The future of physics research, he explained, lay in making more precise measurements of the known physical constants. It was for such precision measurements that the new building was designed. This attitude toward physics was common to the leading thinkers of the period, who from the time of Galileo, through Newton, Faraday, Maxwell, and Helmholtz had developed an elegantly organized description of how events in the physical world happen. Ours was a determined world, precisely predictable according to laws that were clearly understood.

X-RAYS

As typical of the scientific work of the period, Wilhelm Conrad Röntgen was then engaged in a careful study of the densities of various crystals. It seems that the immediate occasion for turning his interest to new fields was a publication by Lenard of an experiment with cathode rays striking a thin window from which rays (which came to be called "Lenard rays") were observed to emerge into the surrounding air. Lenard assumed that these were the cathode rays themselves, which penetrated the thin window of the discharge tube and could go a few centimeters further through the air. Röntgen was not so sure. He surmised that perhaps the rays outside the tube were of a different nature, produced possibly by the cathode rays, but of a considerably more penetrating character. He accordingly set up equipment similar to Lenard's but with walls too thick for the cathode rays to penetrate, surrounded his discharge tube with black paper to keep the light from getting out, and had a crystal such as was commonly used to observe ultraviolet light to see what would happen.

How Röntgen saw the fluorescing crystal when the electrical discharge was passed through the evacuated tube is now a matter of familiar history. Otto Glasser sets the probable date of this event as Nov. 8, 1895. From there on, developments were rapid. Before announcing his discovery, Röntgen himself made so thorough an investigation that for the next several years the investigators who rushed into the field added little more than refinement of detail to the statements about the properties of the new rays made in his own initial publications. The effect on a photographic plate, the electrical conductivity of the surrounding air, the slight effect on the retina of the eye, the remarkable penetration but partial absorption of the rays traversing various materials, the sharpness of shadows, unsuccessful attempts to refract, reflect and diffract the rays, even a try at reflecting the rays from a crystal of calcite, were described in Röntgen's publications of 1896. His was a triumph of individually conducted research.

ELECTRONS

It was, however, the uses to which the new rays were put that made this discovery of such extraordinary importance. Within a few months, with the help of x-rays, the existence of ions was demonstrated. For years the idea of electrically charged atoms and molecules had been used in the effort to explain the electrical conductivity of flames and of salt solutions. At a time, however, when one could not be sure even of the existence of atoms and molecules, the theory of ions gained little acceptance. It was when J. J. Thomson and E. Rutherford showed that air made conducting by x-rays could carry just so much current but no more, and that when the exposed air was passed through a strong electric field it was no longer conducting, that people were ready to accept the ionic hypothesis. These were properties predicted on the assumption of ions and for which there appeared no other explanation.

From this discovery of ions came in turn a long line of scientific and practical consequences. Combining the concept of ions with Faraday's laws of electrolysis gave to Arrhenius the firm basis for the theory of electrolytes, which gave impetus to new developments in physical chemistry. Johnstone Stoney noted that this theory required that the charges on each ion should be small multiples of a definite unit, for which he suggested the name "electron." J. J. Thomson surmised that cathode rays consist of tiny "corpuscles" carrying negative charges of this magnitude, and by a brilliant series of experiments measured approximately the charge and the mass of these "electrons." Here was a particle 2,000 times smaller in mass than the lightest atom. What had been named "the thing that can't be cut" is therefore itself composed of smaller parts. Thus came our knowledge of the electron and the beginning of our effort to learn the structure of the atom.

What the discovery of the electron has meant is in itself a story worth many volumes. Its exploitation in the electron tube, through the radio, sound-movies, radar, etc., has changed our social life, our economy, our political development, and has played a crucial part in the outcome of the recent war. On the scientific side, one of the many uses of the electron has been as an object for study while moving at speeds approaching that of light. It was the new phenomena thus presented that led to the theory of relativity, with its far-reaching implications concerning the relations of time and space and of matter and energy.

RADIUM

The early x-ray tubes of the type used by Röntgen glowed with a green fluorescence while emitting x-rays. Though Röntgen himself knew the two phenomena were of entirely different origins, Becquerel started from this observation to search for possible penetrating radiation that might be emitted by natural salts that show fluorescence. Among such fluorescing materials are various compounds of uranium. When these

materials were placed on a black paper-covered photographic plate, they left their images. It was immediately noted that the non-fluorescent compounds of uranium were just as effective as were those that showed fluorescence. However, the discovery of radioactivity had been made. Here were natural materials which of themselves emit rays having effects like x-rays.

There followed an intensive study of the materials that show this remarkable characteristic of radioactivity. In addition to the then familiar elements uranium and thorium, polonium and radium and a score of other new radioactive elements were discovered. Rutherford, Soddy, Mme. Curie, and many others shared in showing how one atom emits a positively charged helium atom or a negatively charged electron and becomes an atom of different chemical properties, a natural transmutation from one chemical element to another. The energies involved in these radioactive changes were a million times greater per atom than those in ordinary chemical processes such as combustion. But no way could be found whereby the rate of transformation from one element to another could be changed. This rate was one of nature's established facts.

By the use of rays emitted by radioactive materials many important discoveries were made. Among them was the fact that each atom has within it a tiny "nucleus," only a ten-thousandth the diameter of the atom itself, which possesses nearly all of the atom's mass. By bombarding various substances with the alpha particles (charged atoms of helium) thrown off by radium, and noting how these particles were deflected by the materials they traversed, Rutherford was able to show that the nucleus of each atom has a positive charge which in electron units is equal to about half of its atomic weight. Around this nucleus circulates an equal number of negative electrons, forming a kind of atmosphere. Thus was blazed a trail which has led to the complete solution of the electronic structure of the atom.

Then came the remarkable discovery of atomic "fission." As a result of shooting an alpha particle from radium against an element of low atomic weight, such as lithium or beryllium, a new kind of particle called a "neutron" is produced. This particle is like the nucleus of a hydrogen atom except that it has no electric charge. If a neutron in turn falls on an atom of the special kind of uranium that has atomic weight 235, the nucleus of the atom is split into two roughly equal pieces and in the process emits further neutrons. If these neutrons are in turn caught by other atoms of U-235 the process is repeated, emitting still further neutrons, and so on indefinitely. Each such "fission" liberates a hundred times as much energy as is given out in the already highly energetic process of radioactive disintegration. This is the atomic chain reaction which goes on explosively in the atomic bomb or in a controllable manner in the chain-reacting piles used to make the plutonium used in such bombs.

Not only did the x-ray tube fortuitously guide us to the hidden store of atomic energy. At many stages, also, studies of x-rays and radioactivity have been intertwined, so that the growth of each subject has been connected intimately with the other. Now in bringing the greatest of all wars to a dramatic close, and in making available a source of energy vastly greater than the fuel at man's disposal, atomic fission has justified all the hopes of the Fermis, Rutherfords, Curies, and Röntgens, whose labors have brought us this Promethean gift.

THE NATURE OF THINGS

For understanding the nature of the world we live in, however, the use of x-rays themselves has during the last fifty years been perhaps the most effective of our methods of research. In 1912 von Laue and his collaborators found that x-rays could be diffracted by crystals just as light is diffracted on passing through a finely woven cloth. This showed at once that x-rays act like waves, just as light does, and also that crystals are indeed composed of regularly spaced layers of particles.

Investigations by the Braggs and others demonstrated that these particles are, in fact, the chemical atoms, and from the manner in which they diffract x-rays it was possible to learn the exact arrangement of these atoms in all the ordinary crystals. On the other hand, led by Moseley, the study of the spectra of elements used as the targets of x-ray tubes showed remarkable results. A regularity appeared in these spectra that made it possible to arrange the elements in a simple series of atomic numbers, starting with hydrogen as one and continuing to uranium as 92. Combined with the theory put forward at the same time by Bohr, it became evident that this atomic number is the number of electrons belonging in the atmosphere of each atom. Thus another important step was taken in learning how atoms are made.

With regard to its effect on our attitude toward the world, the most unexpected and far-reaching discovery of modern physics is perhaps that all the elementary pieces of which things are made have the characteristics of both waves and particles. This paradoxical duality came to light first in experiments on the nature of x-rays, which can be diffracted as waves from a ruled grating or can collide with an electron as one billiard ball bounces from another. This supplied the final evidence needed to establish a general "quantum" theory of mechanics that would apply to particles of atomic size as well as to ordinary things. The theory based on these experiments with x-rays concludes that all particles should show certain characteristics of waves, and that, as a result, the future of events on an atomic scale is predictable only as a statistical probability. Electrons and neutrons and atoms, in fact all kinds of things on which it has been possible to make the tests, show the predicted properties of both waves and particles, and the actions of these things are found to be indeterminate to just the predicted degree.

According to the mechanics that Röntgen knew, as Laplace once said, an intelligence so comprehensive that it would know completely the existing physical state of the world should see both the past and the future as if they were present. The result of the new quantum mechanics is, on the contrary, to show that there is a necessary range of uncertainty in any prediction of the future. For atomic events, and all larger happenings, such as the explosion of an atomic bomb, in which the result depends upon some individual atomic event, the uncertainties thus introduced into future actions are so great that only statistical statements as to what will probably happen have any significance. In the case of astronomical phenomena we deal with occurrences in which so many actions are concerned that the statistical predictions amount to practical certainty. As to the uncertainty of human actions, which depend upon nerve currents involving small numbers of molecules, the degree of uncertainty is unknown. We can merely say that if physics is the sole determiner of human events and our intentions are of no effect, then our future actions are not determined by the present situation, but probably within rather wide limits are a matter of chance. Since the day that Lucretius, in his *De Rerum Natura*, asked how free will was to be reconciled with a world whose atoms are governed by pushes and pulls, men have felt that the determined world of science presents a formidable barrier to belief in the effectiveness of purpose. For those who have grasped the meaning of the quantum mechanics, this barrier has ceased to exist.

HISTORICAL SIGNIFICANCE OF RÖNTGEN'S DISCOVERY

For the person who is concerned with the growth of the distinctively human attributes of man, it is such consequences as these that are the true measure of the greatness of Röntgen's work. If, indeed, science is the great intellectual quest of the modern world, his discovery is one of the greatest achievements of the age. There are those, however, who want to measure importance in dollars, or in the shaping of national destiny, or in terms of human life.

Even in such practical terms the discovery of x-rays should be reckoned as an outstanding event in man's history.

As to human life, one could show that the direct effect of the use of x-rays and radium in diagnosis and therapy has saved a number of lives that is comparable with the number of soldiers killed in a world war. In terms of dollars, the money spent by the United States in building and using radio, radar, and atomic bombs, to mention only a few of the industrial consequences of Röntgen's discovery, has during the recent war been several per cent of the total national income. As to the shaping of political events, it is such factors as the radio with its nation-wide broadcasts of news and music and advertisements, that make our nation a cohesive unit.

Now as we face the future of civilization, what are the great factors that shape our thinking? As one commentator has expressed it, the single fact of the atomic bomb in the hands of America and Britain dwarfs the rest of the war situation into relative insignificance. As a result of the search into the nature of things which x-rays initiated, man has found a new basis on which to organize his world.

It may be correctly said that if Röntgen had not discovered x-rays, someone else would probably have found them within a year. It is true, likewise, that this discovery was itself based on a foundation of painstaking and brilliant researches made by many others in previous years. The discovery nevertheless is properly recognized as marking the beginning of a great new era. First it was the era of modern physics. This then developed into a period of vigorous industrial and social growth such as could not have arisen without the stimulus of the new scientific discoveries.

Perhaps, after all, the greatest human meaning of Röntgen's work lies in the increasing interdependence of people's lives in the world that he has helped to bring into being. This interdependence means a greater need for co-operation. This in turn means that the post-Röntgen world is one in which love of one's neighbor, as expressed in the willingness of each to work for the other, becomes a matter of rapidly increasing value. It is, indeed, such events as these that shape the destiny of man.

Washington University,
St. Louis 5, Mo.

1895  1945

A Half Century of Roentgen Rays in Industry

GEORGE L. CLARK, Ph.D., D.Sc.

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THROUGH FIFTY YEARS the principal applications of roentgen rays have been to the saving of life and to the pursuits of the peaceful activities of men. It is singularly appropriate, therefore, that the deeply sincere and expressed hope that the semicentennial commemoration of Röntgen's discovery might be observed in humble gratitude by a world at peace has been apparently realized. Along with medical, biological, chemical, and physical sciences, engineering and industry owe an incalculable debt to the discoverer, the centennial of whose birth coincides with the semicentennial of the discovery of the rays which bear his name.

It is still too early to evaluate the contribution made by roentgen-ray testing and research to the war effort, since much confidential information has not yet been released, but it is safe to say that an undreamed of peak in industrial application was reached. Undoubtedly roentgen-ray methods have played an essential part in the development of the amazing atomic bomb. On the other hand, much valuable information has been gained to aid in the search for the molecular structure and synthesis of life-saving penicillin, DDT, sulfa drugs, and many other compounds. Bomber and fighter plane motors were doubled in horsepower for the same weight of light alloy castings because roentgen-ray testing and research led to soundness of gross structure and freedom from strain in fine structure. Welded Liberty ships no longer broke in two after roentgen rays were applied to a serious problem of failure. So the wartime story goes—artillery, armor-piercing shells, ballistics from roentgen-ray exposure of a millionth of a second, delicate instruments, storage and dry batteries, synthetic rubber, carbon black, lubricants and waxes, catalysts, chemicals, electron tubes, quartz crystal oscillators for control of radiofrequencies, and innumerable other applications.

How much could Röntgen have foreseen of the practical engineering and industrial uses of the rays which he designated X, at the time of his discovery and at the time of his death? Just as he prophetically warned a complacent world against Adolph Hitler ten years before his rise to dictatorship, so perhaps within his soul the modest physicist of Würzburg could see the march of science and say: "Mine eyes have seen the glory." The jealousies and disappointments which embittered his later years pass away and are forgotten. A half century later he stands in the clear light of fame and acclaim by a grateful world. For roentgen rays are truly one type of light, and light is life.

CLASSIFICATION OF APPLICATIONS

The industrial applications of roentgen rays fall mainly into three classes just as medical uses do. The first of these is radiography, including fluoroscopy—a diagnostic procedure; this also includes the newly developed technic of microradiography. The second, considerably more limited in industry than in the corresponding therapy, involves certain direct chemical and physical effects of the rays. The third application is concerned with the analysis of crystal or ultimate fine structure, depending upon the optical property of diffraction. These three spheres of usefulness will be considered in order, by no means exhaustively, but simply illustrated by examples chosen at random.

RADIOGRAPHY: EXAMINATION OF GROSS INTERNAL STRUCTURE

Engineering materials, especially metal and alloy castings, are constantly a source of weakness. Flaws and cracks in castings are always likely to occur and often are dis-

covered only after a piece has failed, possibly with loss of life, or after expensive machining has been done; it may then have to be scrapped and the work is wasted. If roentgen rays could be used to examine all castings, immediately they would be universally employed, but unfortunately there is a limiting thickness of metal beyond which the rays cannot penetrate. For many years three or four inches of steel was the limit, although greater thicknesses could be penetrated by gamma rays from radium. In the year 1945, however, as a result of the development and commercial use of one- and two-million volt roentgen-ray tubes, this limiting thickness is nearly 12 in. of steel. Metal ingots and castings below this thickness are all capable of roentgen-ray inspection although, owing to the complicated shape of many castings, their examination by x-rays is not always practical.

It is well to remember that radiography is the production of a shadow picture. The shadows exist in the picture because rays are absorbed to different degrees by different media. If we were to radiograph a perfectly homogeneous piece of muscle or steel, we should obtain a photographic plate uniformly blackened because the roentgen-ray absorption would be quite uniform. The absorption of the radiation by any material depends, first, upon the material itself—in general the higher its atomic weight the more absorbent it is—and, second, upon the penetrating power or wave length of the roentgen rays. The latter condition depends, generally speaking, on the voltage which is applied to the terminals of the tube. Thus, according to the first condition, lead is more absorbent than iron, iron more than aluminum, and aluminum more than organic substances such as flesh. At the same time, if we use a tube having a tungsten target, the rays will be more penetrating when generated by 200,000 volts than at 100,000 volts, and so on. If a beam of roentgen rays of suitable penetrating power is passed through an object of varying thickness or varying composition, the emerging rays (which affect the photographic plate) will have differe intensities corresponding to the variatio in the object, and the result will be a mi ture of shadows of varying degrees of i tensity. For example, a hidden cavity i a piece of metal means that the total thic ness of the material is less at that partic lar place, and the roentgen-ray absorptio will also be less; therefore, we shall o tain more intense radiation in that are resulting in a darker patch on the negativ If, instead of a photographic plate, we a using a fluorescent screen, we shall see brighter patch on the screen correspondi to the more intense radiation.

Unfortunately, of the energy repr sented by the roentgen rays that fall o the photographic film only a very sma fraction (less than 1 per cent) has an photographic effect; the remainder simpl passes through the emulsion without affec ing it. The photographic effect, howeve may be increased by the use of suitable i tensifying screens that absorb more of tl rays and in consequence emit actinic ray which reinforce the photographic imag There are many details of correct techn for obtaining sharp radiographs revealin minute defects which must be learne from theory and experience, just as is tr in medical practice. For example, speci cations are rigidly set up by the Army A Forces and other agencies. These invol distance and size of focal spot of the tub protection of the film from scattered an secondary radiation in the specimen, co rect exposure charts, and stereoscopic e posures for locating the depth of a defec When the object has very irregular edge it may be convenient to use a wax impre nated with lead or other heavy elemen Another method is to immerse the spec men in a liquid having about the same co efficient of absorption.

A certain number of patches or crack may occur in a casting and still not be se rious enough to entail its rejection. Th actual significance of the roentgen-ra picture in terms of mechanical strength i a matter for experience in interpretation The positions and dimensions of metalli

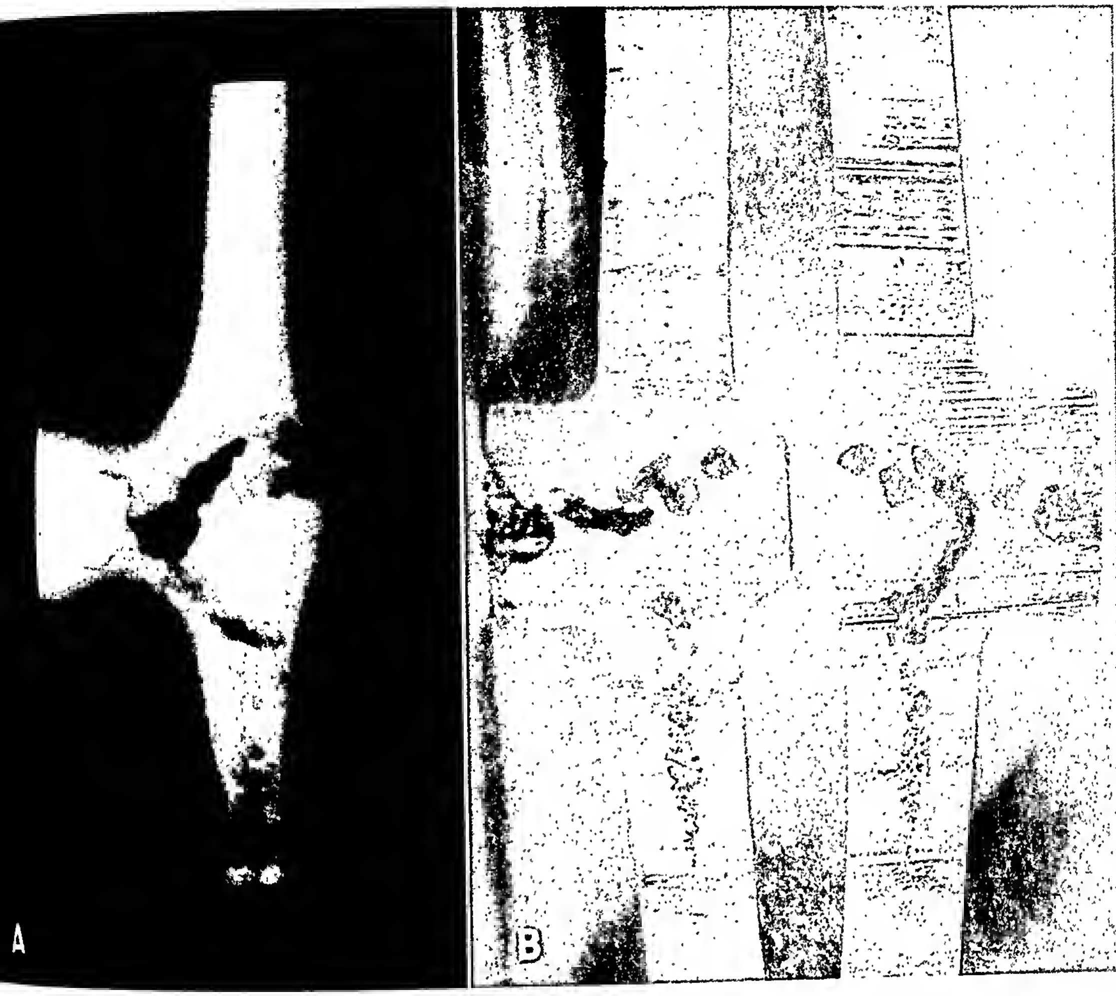

FIG. 1. A. Radiograph of defective aluminum alloy sand casting. B. Defective casting sectioned after radiography. (Courtesy of General Electric X-Ray Corporation.)

flaws may be calculated with great accuracy by stereoscopic methods. Hence the radiograph becomes an infallible guide as to the soundness of material. Usually it may be used as a guide in correcting materials and processes so that they are free from defects and there can be no question of acceptance or rejection. It is doubtful whether dependable castings of the new magnesium alloys ever could have been produced during the war without research guided step by step by radiographic test.

Among the castings and forgings that are at present radiographed on a service routine scale are those for gun carriages, turbine shells and parts, oil stills, airplane parts, locomotive parts, high-pressure steam installations, and expensive steel cylinders, together with many other of specialized importance. The method is in general use in America, and installations are in use for the same purpose in the factories and dockyards of other countries. As already mentioned, the greatly expanded use during World War II of light aluminum and magnesium alloy castings was made possible to a large extent by radiographic control of soundness, both as a routine procedure and as a means of developing correct foundry practice (Fig. 1).

Metallic welding affords another wide field of roentgen-ray usefulness. All welding is liable to faults, and even the best methods depend very largely upon the skill and care of the individual workman. There is no method save radiography of testing a weld without destroying it. As a result of an extensive experience, it is

customary to estimate the mechanical strength of a weld by a mere examination of the radiograph. Inspection of the soundness of welds now ranges from spot welds of thin aluminum foil on airplane wings to welded Liberty ships and the giant penstocks of Boulder Dam and similar structures.

Another application has its main expression in the inspection of assembled articles, such as aircraft instruments, electronic tubes, electric relays and resistances, artillery shells, bombs and rockets (including the proper filling with explosive and incendiary materials and safe inspection of ammunition captured from the enemy), and fuses, where the finished product depends for its proper functioning on the completeness and correct assembly of its internal components. In such cases, elaborate and expensive systems of inspection are often necessary. In many instances roentgen rays afford an accurate means of performing such a check.

Wooden structures, such as airplane and glider parts, railway ties, telephone poles and lead storage battery separators also offer a suitable field for x-ray application. Worm holes, resin pockets, and graining may be determined with great exactness. Roentgen-ray inspection of the roof beams of the aged York Minster in England disclosed in 1938 such a dangerous internal honeycombing from boring of death-watch beetles that immediate replacement was necessary.

In the course of a research on glued joints it was necessary to determine the disposition of the glue. By adding to it a small percentage of a heavy salt, thereby rendering it opaque to the roentgen rays, the dispersion of the glue in the joint was shown with clearness in a radiograph. Much of the success of modern laminated wood as a light and strong structural material is the result of this technic. Motor tires may be examined to determine the position of the cords and the bonding of rubber. Electric insulating materials, such as ebonite and built-up paper materials, may be examined for the presence of impurities and electrically conducting par ticles. Abrasive wheels have been ex amined for cracks, and fireclay pots used in the manufacture of glass have been in spected for the presence of harmful metalli impurities. Roentgen rays have also been used by customs authorities and now by the Army and Navy (see *Life*, Aug. 27, 1945, page 110) to investigate the contents of sealed packages. Real pearls may be dis tinguished non-destructively from imita tion by roentgen rays, since the real pear emits visible fluorescence under the actio of the rays. The real pearl also discloses a series of layers or "growth-rings" from th center outward, to distinguish it from th cultivated, or Japanese pearl, which has a artificial center upon which is deposited thin nacreous layer. Diamonds, which ar very transparent to roentgen rays, may b distinguished from imitations, which as rule are much more opaque. The use o these rays to demonstrate the fit of shoe and boots is now a familiar sight in a sho store. The exact measurement of the fi of screw threads is a matter that has give rise to a good deal of difficulty; radiog raphy is now being used for this purpos with remarkable success.

Entirely new is the "instantaneous" ra diography developed by Westinghouse A condenser discharge through a specia tube provides a roentgen-ray beam of such great intensity that an exposure of th order of a millionth of a second is possible Thus objects in rapid motion may be ra diographed. The most important applica tion has been to the science of ballistics since the course of bullets through variou materials is easily followed.

Prior to 1928, Dr. Heilbron, of Amster dam, conducted some very remarkable and beautiful experiments with roentgen rays on pictures painted by old masters. The pigments of modern painters are, in gen eral, much less opaque to the rays than those used many years ago. Dr. Heilbron was able to produce evidence of extraor dinary alterations having been made in some pictures. In one picture, by Cor nelis Engelbrechtsen, the roentgen ray

showed the figure of a vested priest which had been covered at a later date by the portrait of a woman. This hidden feature of the original painting had remained undiscovered for four hundred years. Another picture, a representation of the Madonna by Geertgen van St. Jans, was shown by the roentgen ray to have originally included an infant in the arms of the figure, which had subsequently been painted out. This method has been

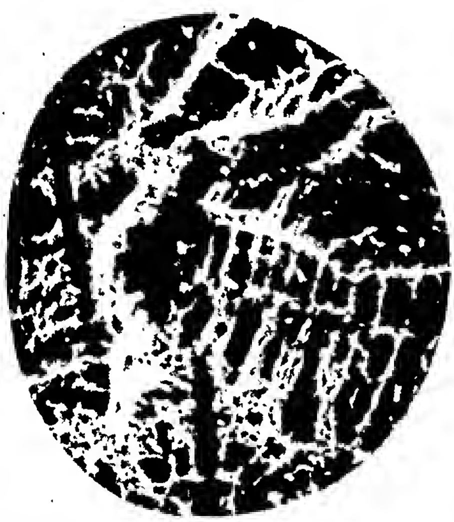

Fig. 2. Microradiograph of commonly used wartime aluminum alloy; copper-rich constituent white. ×100.

greatly extended by Burroughs of the Fogg Art Museum of Harvard University, Rawlins of the National Art Gallery, London, and others, with the result that a roentgen-ray laboratory is an essential part of any good museum. Even the most famous painting in America, Reynolds' Blue Boy, in the Huntington Gallery, has not escaped. Recently an area above the head appeared to have a peculiar light reflection (*pentimento*). Radiographic examination showed the figure of a man over which the Blue Boy had been painted. The light spot corresponded to the white stock around the neck of this underlying figure on a canvas which had been cut down for the Blue Boy.

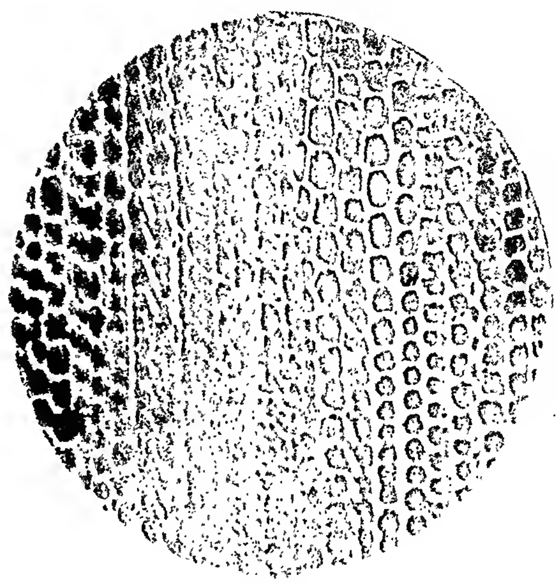

Fig. 3. Microradiograph of tangential section of wood. ×*c*.100.

The development of radiographic apparatus has resulted in the production of mobile units and small and portable equipments for various purposes, among which may be mentioned a set for the use of plumbers and builders to enable them to locate the position of wires and pipes in the walls and floors of buildings. Automatic equipment with moving belts permits quality classification, usually by visual fluoroscopy, of many products, making possible elimination of candy containing foreign bodies, separation of juicy and pithy citrus fruits, and detection of damaged or contaminated food products of many kinds. Trucks and railway cars have been equipped with heavier units for rapid transportation to fixed engineering structures.

MICRORADIOGRAPHY

A logical extension of radiography is to the examination of very small objects, the image of which must be enlarged. Since there are no magnifying lenses for roentgen rays, it follows that recourse must be taken to enlargement of radiographs registered on very fine-grained photographic emulsion, such as the Lippmann, or Eastman 548-0. Since 1938, this technic of mi-

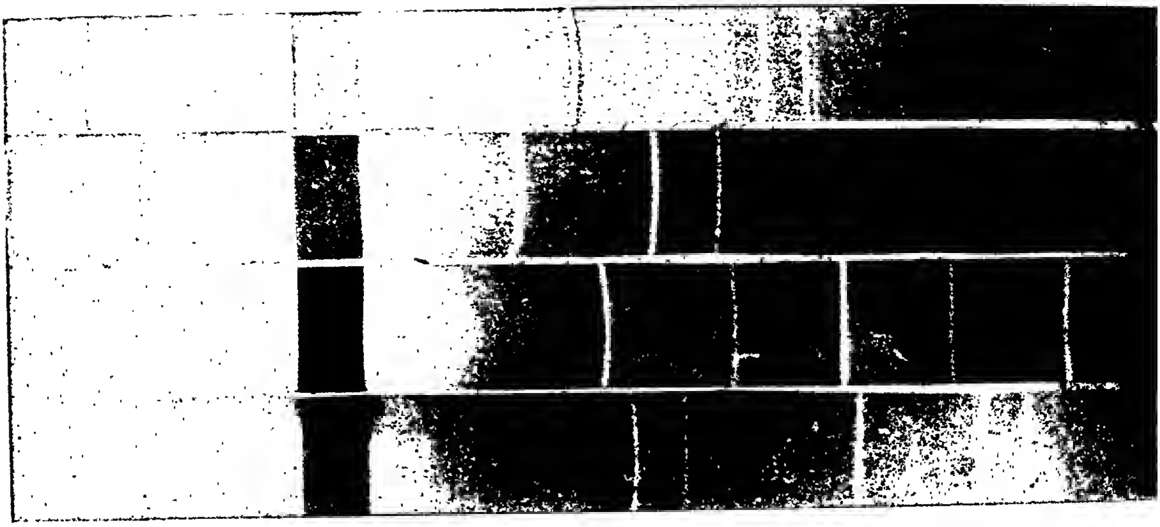

Fig. 4. Diffraction patterns. A. Magnesium (hexagonal close packed). B. Copper (face centered cubic C. Tungsten (body centered cubic). D. Silicon (diamond cubic).

croradiography has been developed as the result of the work of Clark and his associates at the University of Illinois into a successful and important practical method, especially in the field of metallurgy. The technic is remarkably simple, involving only transmission of roentgen rays generated at voltages below 30,000 volts through a specimen a few thousandths of an inch thick which is in contact with the fine-grained photographic film. The image is then photographically enlarged. Each separate phase in a complex alloy, having a different absorbing power for roentgen rays, can be delineated; by a simple calculation from absorption coefficients, the proper wave length may be selected for maximum differentiation between two or more phases in the most complex bronzes and other important commercial alloys. Biological materials of very small size can be similarly photographed, depending simply on differences in density within the structure or following differential "staining" with absorbing materials. Typical illustrations are the microradiographs of a commonly used aluminum-copper alloy in which the copper appears as white streaks (Fig. 2) and of sections of wood (Fig. 3). A recent accomplishment involved specification of steel for vitreous enameling, since steels of the same composition and structure acted very differently, in some cases causing enamel to shatter. Microradic graphs proved that microporous channel could cause diffusion of gases through th metal with disruption of the bond betwee steel and enamel. The microradiograp supplements the familiar photomicro graph, but has the advantage of a three dimensional view of a specimen in con trast with the two-dimensional view of a etched, highly polished surface in th photomicrograph. Thus the microradic graph is well adapted for stereoscopy.

DIRECT PHOTOCHEMICAL AND PHYSICAL EFFECTS

Through fifty years there has been ac cumulating a fund of information on th direct biological, chemical, and physic changes produced in matter by absorptio of roentgen rays and consequent libera tion of high-speed electrons. The cance cell is destroyed by such a process; mu tations in species are produced by th useful tool of the geneticist; the photo graphic effect is the best example of chemi cal change, along with decomposition of variety of organic compounds and oxida tion-reductions. These have considerabl greater biological or photochemical signif cance than truly industrial applicatior However, a few successes are of unusu interest. There have been many attempt to use roentgen rays to sterilize package

and bales of such natural materials as dates, figs, cereal grains, and other food products. The organisms have usually been so resistant that impracticable doses of radiation are required, in comparison with gaseous disinfectants.

Another common application has been coloration of gems, minerals, and glass by radiation. Unfortunately, many of these attempts have been at the hands of unscrupulous dealers in antiques. An example of this process, however, has proved an outstanding success during the war and saved millions of dollars. The Reeves Sound Laboratories discovered that when quartz oscillator plates, used to control radio frequencies and produced in very large numbers for the Army Signal Corps, were irradiated with roentgen rays, they became smoky in color and at the same time the *oscillation frequencies* decrease. Thus thousands of plates that have been over-shot in frequency (or ground too thin, aged, or reclaimed) are salvaged. The frequency adjustment is brought under continuous visual control by oscillating the crystal in its holder in the roentgen-ray beam until it reaches the desired frequency. The frequency change brought about by radiation can be reversed and the original value restored by baking the plate at temperatures over 175° C. This process undoubtedly may be applied to a wide variety of other materials. It is to be distinguished from another roentgen-ray technic applied to quartz plates—namely, back reflection control of the original cutting and grinding from natural quartz crystals, as mentioned in the following paragraphs.

ROENTGEN-RAY DIFFRACTION: ANALYSIS OF FINE STRUCTURES OF MATERIALS

Another newer and less familiar branch of roentgen-ray science applied to industrial problems depends upon the fact that solid crystalline materials serve as diffraction gratings for the rays by virtue of the regular arrangement in space of the ultimate atoms, ions or molecules, just as closely ruled lines on glass or metal serve as a diffraction grating and produce a spectrum of ordinary light. This interaction between roentgen rays and crystals was predicted and experimentally proved by von Laue in 1912, and given its simplest expression in the familiar Bragg law: $n\lambda = 2d \sin \theta$, where n is an integer (the order of the spectrum), λ is the roentgen-ray wave length, d is the interplanar spacing or distance between two identical planes of atoms or molecules in the crystal, and θ is the angle of incidence of the beam on this set of planes. Thus every crystalline chemical element or compound produces a diffraction pattern which is uniquely characteristic of the particular kinds and arrangement of atoms or molecules which are the ultimate building blocks of the crystalline architecture.

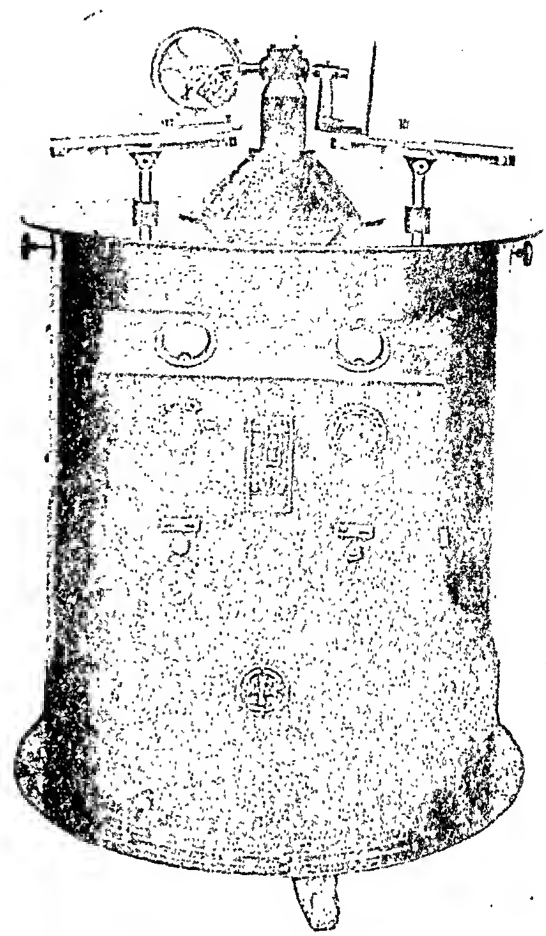

Fig. 5. Typical commercial diffraction unit. (Courtesy of Hayes Scientific Appliances.)

The pattern may be used to identify the solid exactly as it is without solution in a liquid or other change. It is a compara-

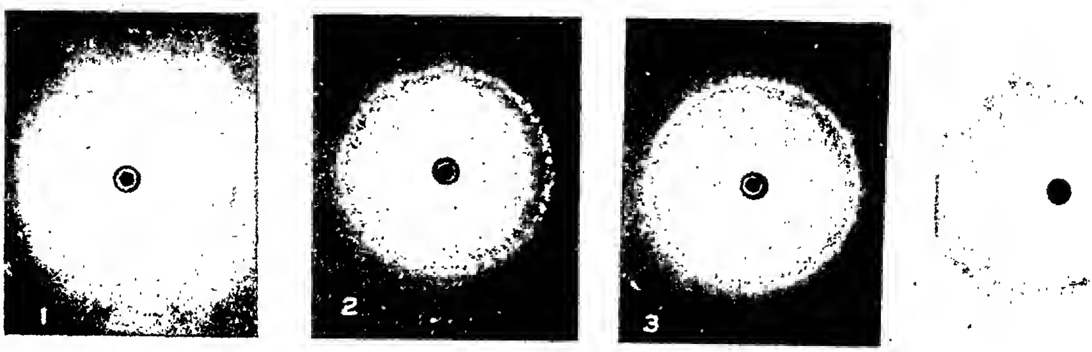

Fig. 6. Back-reflection patterns from aluminum alloy airplane motor casting.

tively simple matter to identify an unknown material if a library of standard patterns of known pure materials is available for matching. To this end the American Society for Testing Materials, in conjunction with the Physical Society of London, has issued a card index of diffraction patterns for about 10,000 compounds, based on the original Dow-Hanawalt Tables. For this identification the material is finely powdered and a so-called powder pattern or spectrogram of sharp lines is photographed. By rapid methods of comparing the three most intense lines with recorded values, the unknown may be readily discovered, if there is a standard pattern for it in the index (Fig. 4).

Thus the practical industrial identification of any solid material may be carried out quite simply without proceeding to the more difficult technics of determining the actual crystalline architecture, or precise scheme of arrangement in space of atoms or molecules, or even of atoms within molecules, particularly for organic compounds.

There are a number of diffraction technics and types of cameras. A carefully collimated train of parallel roentgen rays, usually with one wave length, is directed through, or reflected from, the surface of the specimen, which may be a powder, aggregate, fiber, or single crystal, which may be stationary, rotated, or oscillated. The diffraction pattern is registered on a photographic film, stationary or moving, flat or curved, at a fixed distance from the specimen. In the United States four manufacturers produce, chiefly for industrial use, complete multiple diffraction units which two or four patterns may be pho graphed simultaneously (Fig. 5).

Until recently complete structure anal ses were largely confined to academic la oratories, from which came a growing n crystal chemistry. Suddenly the pro lems of identity and synthesis of quini penicillin, synthetic rubber, alloys, and long list of essential materials have r quired the practical use of the ultima analyses. The electron density conto map of a complex molecule, derived b mathematical Fourier analysis from i tensity data, is now commonly deduced industrial research laboratories. Many the newest industrial materials have be the direct result of the guidance of roen gen-ray diffraction research and testin Natural materials such as minerals, cla and soils, cellulose, proteins and other te tile materials are frequently studied.

In addition to analysis of crystalli architecture, diffraction patterns have t important function of indicating texture the actual condition of a specimen in tern of grain size, orientation, effects of rollin drawing, fatigue, strain, annealing, agin and other processes. During the war hun dreds of thousands of quartz plates for co trol of radio frequencies have been properl cut and ground for the Signal Corps of th Army by diffraction control in nearly aut matic apparatus employing Geiger-Mülle counters for instantaneous check instead photographic films. Airplane motor cast ings have been so improved by roentge ray back-reflection control (Fig. 6) tha strain is eliminated and horsepowe

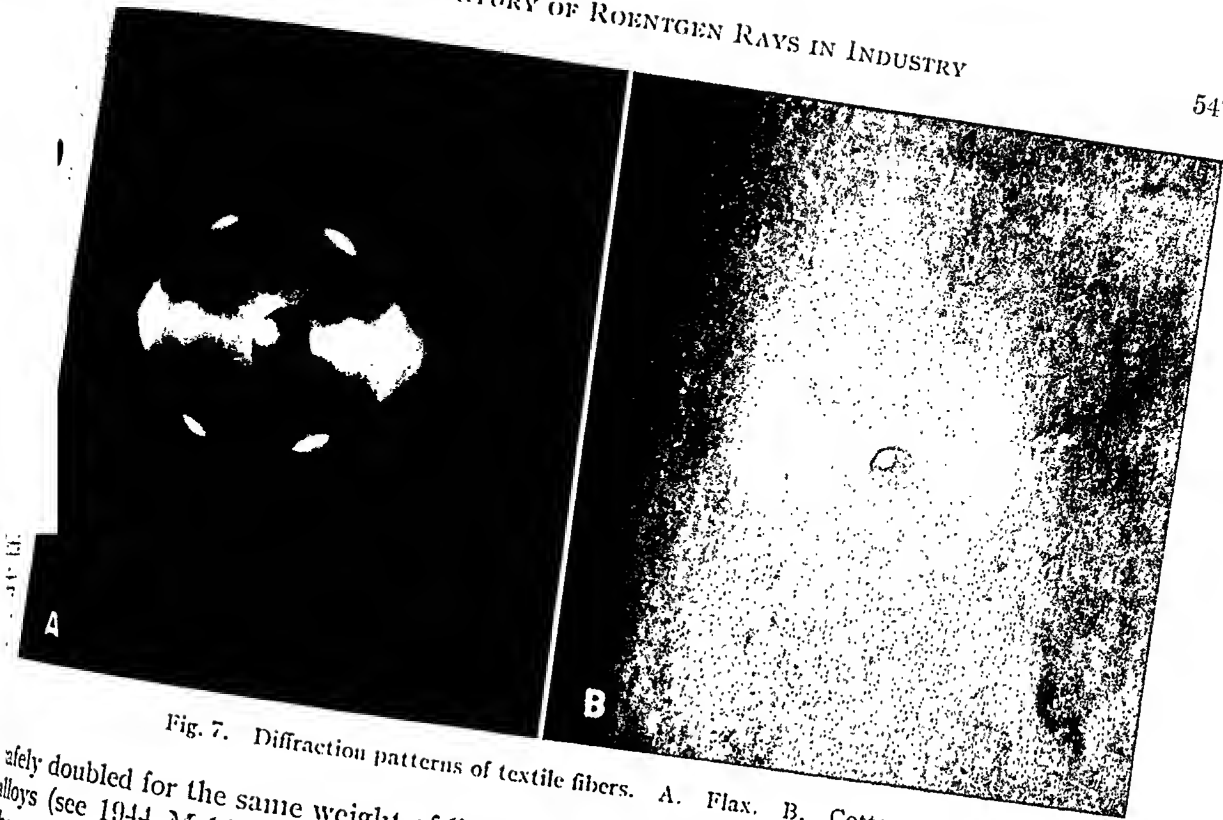

Fig. 7. Diffraction patterns of textile fibers. A. Flax. B. Cotton.

afely doubled for the same weight of light alloys (see 1944 Mehl Award Lecture by the writer, before Congress of Metals[1]). Carbon blacks for rubber reinforcing, charcoal for gas masks, storage batteries (grids and active material), explosives, chemicals, antiseptics and medicinals, waxes and coatings, welded Liberty ships, fluorescent materials, surgical sutures and membranes, natural and synthetic textiles (Fig. 7), elastic polymers and plastics, pigments, electroplatings, lubricants, instrument pivots, brasives, adhesives, wood and lignin, iler scale, glass, soaps, parts of V-1 and 2 German bombs—these are but a few of materials of industrial and wartime im- ance to which roentgen-ray diffrac- methods have contributed fundamental research information and routine production control; for practical behavior in use so frequently depends on the ultimate structure and texture after gross soundness is assured by radiographic inspection.

In 1945 Dr. C. S. Barrett of the Carnegie Institute of Technology announced a new microscopy of potential value in physical metallurgy and in other fields, which de- ends on roentgen-ray diffraction. This new adaptation supplements optical and electron microscopy and microradiography. It differs from usual technic in employing a fine-grained photographic plate in contact with or very close to the specimen, upon which a beam of characteristic x-ray strikes. The diffraction image is enlarged just as in the case of microradiography. These diffraction micrographs show the places where inhomogeneous strain is concentrated. Along planes where slip has occurred throughout the interior of crystals and polycrystalline grains there is a local bending or rotation of the crystal lattice. At such points the efficiency of roentgen-ray reflection is increased and a dark line is produced on the photographic plate. Measurement can be made of the amount of rotation (usually less than 0.1°) and the thickness of the distorted layer. Thus strain, plastic deformation, twinning, distortion from scratches and from cutting tools, annealing, recrystallization, coring, clustering of similarly oriented grains, age-hardening, and superlattices are all subjects for investigation by the technic. Sizes and shapes of polycrystalline grains are shown in truly amazing photographs. Since these diffraction micrographs register

[1]Industrial Radiography 3 (No. 2): 13, 1944.

the effects in individual grains (while ordinary diffraction patterns are the summation of effects from large numbers of grains), it is possible to identify microconstituents from the directions of diffracted rays measured with two films at different distances, and application of the Bragg law. Thus non-destructive microanalysis on individual particles is one of the useful applications.

From the foregoing highly condensed and inadequate account, it is evident that volumes would be required to record adequately the achievements of roentgen-ray methods in industry over a half century, with the result that better, safer, more economical materials of everyday life have been produced. Such an attempt is being made in the fourth edition of the writer's "Applied X-Rays" now in preparation, which will be humbly and gratefully dedicated to the eternally living memory of Wilhelm Conrad Röntgen.

University of Illinois
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1895  1945

Organized Roentgenology in America

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THE RAPID advance of roentgenology in America owes much to the association of radiologists in national and local organizations. The three large national bodies are the American Roentgen Ray Society, the Radiological Society of North America, and the American College of Radiology, and it is to these that the present paper is chiefly devoted. These societies, together with the Section on Radiology of the American Medical Association and the American Radium Society, participated in the organization of the American Board of Radiology in 1934 and through their representatives sponsor its activities. Certification by the Board, after meeting its requirements, marks a radiologist as well grounded in his specialty and qualified to practise it in one or more of its special fields.

AMERICAN ROENTGEN RAY SOCIETY

On March 26, 1900, less than five years after Röntgen's great discovery, a group of workers with x-rays met in St. Louis and organized the "Roentgen Society of the United States." Eight states, mostly mid-western, were represented. The meeting was held in the office of Dr. Heber Robarts, editor and publisher of the *American X-Ray Journal*, which had been launched in 1897, and Dr. Robarts was elected President. The first annual meeting of the new society was held in New York, at the Grand Central Palace, Dec. 13 and 14, 1900, and the name was then changed to the American Roentgen Ray Society. Under that name the organization has continued without interruption up to the present time, meeting annually for the transaction of business and the presentation of a scientific program, except on two occasions when wartime restrictions prevented. Since 1939 a series of Instruction Courses has been a popular feature of these annual meetings.

For many years meetings were also held by the Eastern, Central, and Western Sections of the Society. In 1925, however, following the establishment of a Section on Radiology by the American Medical Association, the three Section meetings were discontinued, at about the same time that the Radiological Society of North America gave up its mid-annual sessions.

Those of us who entered the practice of roentgenology after it was firmly established as a specialty in medicine find it hard to evaluate the difficulties that beset the pioneers in our art. Since that winter night when Röntgen first saw on the glowing screen the shadow of the bones of his own hand, the rays which he named "X," the unknown, have appealed strongly to the imagination. The method of their production, their mysterious penetrative power, the crackling sparks, the whir of machinery, the darkened rooms, and the ghostly glow of fluorescent screens, have all suggested that the odor of ozone is not infrequently mingled with that of brimstone. So it is not surprising that for a time after Röntgen's spectacular discovery both the diagnostic and therapeutic use of his weird rays fell into disrepute. The early records of the Society show the names of many applicants, some of whom were accepted, whose only qualification for membership was the ownership of a static machine. But the ancient rosters also list the names of many whom we delight to honor, men who were not only great roentgenologists but were also great doctors, who guarded jealously the honor of the Society and the integrity of their profession. The vigilance of these men, their unselfish devotion to their profession, and the high standards they established and maintained for themselves are responsible in great measure for the respected place roentgenology now enjoys in every field of medicine. Largely as a result of their ef-

forts, the American Roentgen Ray Society became in a decade what it is today, a group of real specialists who respect one another and themselves.

The papers and discussions of the 1900 and the 1901 meetings appeared in the *American X-Ray Journal*. Transactions of the meetings from 1902 to 1905 were published in volume form. In October 1906, the *American Quarterly of Roentgenology* was established by the Society with Dr. Preston M. Hickey as editor, and was published for one year. Transactions again covered the meetings of 1907 and 1908. The *Quarterly* was then re-established, and Volume 2 appeared in December 1909, Hickey continuing as editor. In November 1913, the *Quarterly* took its present form and became the *American Journal of Roentgenology*, New Series, published monthly. This journal has functioned successfully under the successive editorships of Dr. Hickey until 1916, James T. Case until 1918, Harry M. Imboden until 1924, Arthur C. Christie until 1930, and Lawrence Reynolds since 1930. Since the journal became also the official organ of the American Radium Society in 1923, it has been known as the *American Journal of Roentgenology and Radium Therapy*.

Charles C Thomas, of Springfield, Ill., has published the *American Journal of Roentgenology* since 1930, and has taken justifiable pride in its technical excellence. Its paper, typography, and illustrations are of the highest grade and accord well with the notable character of its contents. At the present time there are 4,400 paid subscribers.

Of all the brave spirits who rendered outstanding service to the science and the art of roentgenology in the early years, Eugene W. Caldwell will be longest and most gratefully remembered. Even before the turn of the century he was devoting his entire time to roentgenology. He had a sound scientific education, but he realized early in his career that roentgenology should be practised by physicians, and accordingly worked for and finally, in 1905, received his medical degree. While he was a medical student he published a volume in collaboration with William Allen Pusey entitled "The Practical Application of the Roentgen Rays in Therapeutics and Diagnosis." Perhaps the best evidence of the respect and affection of his colleagues is the fact that after his death the American Roentgen Ray Society established the annual Caldwell lecture. To be asked to deliver this lecture and receive the Caldwell medal is one of the greatest honors that can come to any roentgenologist, or to any scientist in an allied field.

RADIOLOGICAL SOCIETY OF NORTH AMERICA

Unofficially, St. Louis was also the birthplace of the Radiological Society of North America. In the summer of 1915 several radiologists met in the former offices of Russell D. Carman in Olive Street, then occupied by M. B. Titterington, and decided to organize a mid-western society. With the help of George W. Brady, invitations were sent to the radiologists of Missouri, Illinois, and Iowa, and an organization meeting was held Dec. 15 and 16 at the Hotel Sherman in Chicago. There were about thirty charter members. Fred S. O'Hara was elected President. The name chosen for the new organization was the Western Roentgen Society.

There were several reasons for a new society. The American Roentgen Ray Society had developed into an organization of fully trained specialists. Membership in it was not easily acquired, since applicants were expected to have done some valuable original work before they were elected. The annual meetings of the older society were almost invariably held in eastern cities, and the cost, in money and time, of attending them was high. Probably the most compelling reason for forming a new society was the firm belief held by its founders that there should be a place in organized radiology for young men, who should be encouraged to develop within the organization. There was a paragraph in the newly adopted constitution which is still retained. It provides for

members-elect, whose qualifications are the same as those of active members except that the applicant need have devoted the major portion of his time to the practice of radiology for only one year instead of three. The founders and the older members have been proud of the fact that no member, regardless of his obscurity or the modesty of his attainments, has ever been denied the right to raise his voice in either the scientific or executive sessions of the Society.

Because it filled a need, and also because of its democratic spirit, it is not surprising that the new group grew and prospered rapidly. As indicated by the name chosen for it, the founders had expected the Society to be and remain a western organization. The original by-laws contained a provision that the annual meeting should be held in Chicago. In three years, however, it had 472 members in 38 states. It was, obviously, no longer a "Western" Roentgen Society, and the name was accordingly changed to its present one on Nov. 22, 1918.

Although the Society has grown steadily in size and influence, it has not been without vicissitudes. On two occasions it has been rent by internal dissension, in each instance concerned with the publication of its journal. The first official publication of the Society was the *Journal of Roentgenology*, with the late Bundy Allen as editor and business manager. Because of lack of funds, the journal appeared only sporadically from May 1918 to the end of 1919, when its name was changed to the *Journal of Radiology*. This journal was to be published monthly, but only five numbers were printed in 1920. At the annual meeting that year a group of members of the Society subscribed to stock in the Radiological Publishing Co., a non-profit organization established to ensure publication of the journal. For some reason that has never been clearly explained, a small group of stockholders seized control of the publishing company and the journal, and it was not until September 1923, after long, expensive, and bitterly contested legislation, that the Society regained authority over its own journal. At that time RADIOLOGY was started. It has continued since then without interruption under the successive editorships of M. J. Hubeny to 1930, Leon J. Menville to 1940, and Howard P. Doub to the present time.

During the annual meeting of the Society in 1929, the Chemical Foundation offered to subsidize the publication of RADIOLOGY, and the Executive Committee, with some misgivings, recommended that the offer be accepted. It soon became apparent, however, that the officers of the Foundation intended to have a voice in the management of the society. Late in 1931 the Foundation demanded that the Society change its constitution and by-laws and institute a form of government abhorrent to nearly all its members and entirely contrary to the democratic ideals on which the Society had been founded. Although a threat to withdraw the support of the Foundation accompanied the demand, it was promptly rejected, and the relationship between the two organizations was discontinued a few months later.

Although those who were compelled to engage in these controversies may now regret their necessity, the broken friendships they caused, and the violence and bitterness with which they were waged, there can be little doubt that the Society emerged from them stronger and more firmly united than ever before. They at least established incontrovertibly, and it is to be hoped forever, that the Radiological Society will continue to conduct its affairs for the benefit of its members and the science and art it serves, without interference from without or within.

The Radiological Society has always been generous in its support of its official journal. The time, effort, and money expended upon it have been well repaid in the pride and satisfaction the members have in the growth and steadily expanding influence of RADIOLOGY. It now has about 3,500 paid subscribers, and its technical excellence is hardly to be surpassed by any professional publication.

In the summer of 1925, a month prior to the meeting of the First International Congress of Radiology, the Society took an important forward step when it appointed a committee to study various phases of the problem of standardization of x-ray measurements. This committee, perpetuated as the Standardization Committee, has coöperated actively with the National Bureau of Standards and other agencies interested in this important phase of radiology. Its Technical Bulletin No. 1 on "Dosage Measurements," prepared by Dr. Edith Quimby and Dr. George C. Laurence, was approved at the twenty-fifth annual meeting of the Society in 1939.

The year 1938 was notable in the history of the Society for the institution of the Annual Refresher Courses in subjects of fundamental concern to radiologists. These courses, held in conjunction with the Annual Meeting, are conducted by men of the highest qualifications, and large numbers profit by the opportunity they offer.

The by-laws of the Society provide that, by unanimous vote, the Board of Directors may award the gold medal of the Society to "those persons who in the judgment of the Board of Directors have rendered unusual service to the Science of Radiology." The first recipient of this honor was Heber Robarts in 1919. The list of those who have subsequently received it contains many names of men and women who have contributed lavishly to the sum of knowledge of roentgenology. The medal of the Radiological Society of North America is probably the highest honor that any American roentgenologist can hope to receive.

Russell D. Carman was president of the Society in one of the most trying and critical years of its existence. To project his memory and his achievements, the Society established an annual Carman lecture. The first lecture was delivered, by Carman's friend and co-worker, B. R. Kirklin, in 1934. Lecturers in subsequent years have been A. C. Christie, Jas. T. Case, George W. Holmes, Wm. C. MacCarty, Sr., Francis Carter Wood, Ross Golden, Wm. E. Chamberlain, Eugene P. Pendergrass, and Lawrence Reynolds. To be asked to deliver this lecture is a signal honor.

The Radiological Society now has 1,430 members, and it is financially prosperous. While it is probably the most powerful and influential body of x-ray specialists in the world, its strength does not lie only in its numbers and its wealth. It is strong because of its democracy, its unity and solidarity, and the deep feeling, amounting almost to affection, its members have for the organization they have labored to build and maintain. Those who first attend one of its meetings are impressed by the spirit of friendliness that prevails, and they observe that "everybody seems to have a good time." Surely, the hopes, the ideals, and the aspirations of its founders have been satisfactorily and adequately consummated.

THE AMERICAN COLLEGE OF RADIOLOGY

In response to an invitation issued by Albert Soiland, 21 radiologists met in San Francisco on June 26, 1923, to decide upon the feasibility and desirability of forming an American College of Radiology. After a thorough discussion, it was agreed that such an attempt should be made. During the next few months a total of 70 radiologists became Charter Fellows of the College. The first regular Convocation was held early in June 1924, during the convention of the American Medical Association in Chicago. The College is purely an invitational body and Fellowship in it was at first conferred only by the unanimous vote of the Chancellors. Now more than two dissenting votes in the Board of Chancellors, or more than ten negative votes of Fellows, disqualify a nominee for Fellowship. The number of Fellows in the College was originally limited to one hundred, but this limit has been raised several times and was finally removed.

For a number of years after its organization, the activities of the College were limited to an annual Convocation, a din-

ner, and an oration. During that period many radiologists were doubtful that it was useful enough to justify its continued existence, and its death from inanition would not have been surprising. But it did survive, probably because the governing body, the Board of Chancellors, carried out its task of selecting Fellows with conscientious care. Radiologists were indeed rare who could bring themselves to decline the real and implied honor of election to Fellowship.

During the administration of the late John T. Murphy, who was president of the College in 1936, the Board of Chancellors awoke to the fact that the College could, if it chose, exert powerful and much needed influence in two directions which had previously been neglected by the two scientific societies and by the Section on Radiology of the American Medical Association. Soon afterward the following paragraph was inserted into the constitution:

> "Objects. To establish an organization of radiologists for the purpose of advancing the science of Radiology and improving radiologic service to the sick by means of the study of the economic aspects of the practice of Radiology, and the encouragement of improved education facilities for radiologists."

Acceptance of the dual functions of protecting the financial status of radiologists and promoting better radiologic education proved to be just the stimulus the College needed. Its activities and influence began immediately to expand. The accomplishments of the College in various fields during the last ten years are too well known to require enumeration here.

Another change in the constitution of the College which tremendously increased its power was the introduction of a provision for membership in addition to Fellowship. Ethical radiologists who have satisfied the requirements of the American Board of Radiology are eligible for membership. Members have all the rights of Fellows except that they may not hold elective office or be members of the Board of Chancellors. There are now 488 Fellows and 1,238 members of the College, the total representing more than 90 per cent of all qualified radiologists. These men want radiology to continue to endure as a specialty. In their determination to protect the status of radiologists, they have had to resist those in charge of medical and hospital insurance plans who are attempting to reduce the practice of diagnostic roentgenology to the level of a hospital service. They have had to resist many of their colleagues in their own profession, some of whom sit in the seats of the mighty, who would like x-ray services to be as free to their patients as Wassermann tests are now. So far, their efforts have resulted in a considerable degree of success. Whether they continue to succeed in the trying years that lie ahead through a period possibly of post-war unemployment and depression, depends upon how well we in the rank and file support the College, its Chancellors, its Commissions, and its Executive Secretary.

In 1937, the College decided to employ a full-time executive secretary, and its choice of Mac F. Cahal to fill the position was a particularly happy one. Fully qualified for the position by training and experience, tactful, respected alike by friend and foe, genuinely courteous, yet possessed of unlimited courage, he has been a sword and buckler and an ever present help in time of trouble.

As has already been pointed out, the Board of Chancellors is, in effect, the governing body of the College. It makes all decisions and plans all programs of the activities of the organization. The Board of Chancellors might be likened to the legislative and judicial branches of government. The executive branch is composed of the various Commissions, whose duty it is, with the help of the officers and executive secretary, to carry out the policies decided upon by the Chancellors, under their supervision and under their control. Even so brief a sketch of the College of Radiology as this would be incomplete without some expression of appreciation of the magnitude of the labors of the Chancellors. Those of us who have seen them at work are amazed at

the diligence with which they attack their tasks, the patient study they give their problems, and the wisdom, unanimity, and courage of their decisions.

Finally, while we must admit that the College of Radiology has strayed far from the course plotted by its founders, most of us can agree that the paths it has followed lead in the right directions; that it has assumed desirable functions and fulfilled them with credit to itself; that it has attained a position where it is respected by the medical profession in general, and where it is rendering, and can continue to render, services of inestimable value to the science and art of radiology.

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1895  1945

The Earliest Roentgen Demonstration of a Pathological Lesion in America

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IN THIS YEAR 1945, which marks the one-hundredth anniversary of the birth of Wilhelm Conrad Röntgen and the fiftieth of his epoch-making discovery, it is not amiss to give some thought to the beginnings of radiology in America. It has been the good fortune of the writer to receive a first-hand account of what appears almost certainly to be the earliest use of roentgen rays in this country for the demonstration of a pathological lesion. The incident was described to him by his former teacher, Dr. Gilman D. Frost of Dartmouth College. Dr. Frost's brother, Edwin B. Frost, Professor of Physics at Dartmouth College, was the pioneer roentgenologist, and Dr. Frost was himself present when the film was made.

The actual discovery of x-rays was the culmination of a long and arduous series of experiments conducted in many lands by many scientists. It was on Dec. 28, 1895, that Röntgen submitted his now famous communication to the president of the Physical Medical Society of Würzburg, and within ten days—on Jan. 6, 1896—the news of the discovery was cabled from London to the civilized countries of the world. A translation of Röntgen's original paper appeared in *Nature* (London) on Jan. 23 and was reprinted in *Science* (New York) on Feb. 14, 1896.

So widespread was the interest in the new rays and so great a mass of material was published during the ensuing months that it is impossible to ascertain with absolute certainty when and by whom the first roentgenograms depicting a pathological condition were made in America. The earliest communications to appear in the American literature followed the translation of Röntgen's paper in *Science*, on Feb. 14. Prof. M. I. Pupin of Columbia University, New York, writing under date of Feb. 8, 1896, headed his paper "Röntgen Rays" and, after reviewing the study of vacuum discharges from the time of Faraday, described his attempts to repeat some of Röntgen's experiments.

Pupin made roentgenograms of several objects, including a pair of spectacles in a leather case. He was handicapped, however, by the poor vacuum in his tubes and by the fact that he did not have a static machine. He used a small Leyden jar and covered the ends of his tube with tinfoil. Some of his exposures were of an hour's duration. Pupin describes, also, a roentgenogram of a hand made by A. A. C. Swinton, but this compared unfavorably with a similar photograph made by Röntgen, since the fleshy parts were nearly as strongly marked as the bony structure. This the photographer attributed to over-exposure, but Pupin believed it to be due rather to under-exposure. Like many other early physicists, Professor Pupin foresaw the practical applicability of this new method of photography to surgery, but there is no statement to indicate that at this early date he had made a roentgenogram of a pathological condition.

In the same issue of *Science*, there appeared a short paper by Prof. Edwin B. Frost of Dartmouth College, Hanover, N. H., describing his experimental work with the new rays. It was dated Feb. 4, and the concluding paragraph ran as follows:

> "It was possible yesterday [Feb. 3] to test the method upon a broken arm. After an exposure of 20 minutes the plate on development showed the fracture in the ulna very distinctly."

Professor Frost had available in the Physics Laboratory at Dartmouth several Crookes tubes, a static machine (Holtz), an induction coil, and Grove batteries. One tube proved superior to all others.

Fig. 1. Photograph taken in the Physics Laboratory, Reed Hall, Dartmouth College, Hanover, N. H., on Feb. 3, 1896. Prof. Edwin B. Frost is sitting, watch in hand, on the left. The patient, Edward McCarthy, is seated to the right of the table. Dr. Gilman Frost is standing to the extreme right, while Mrs. Gilman Frost observes history in the making.

The apparatus is clearly depicted; a special Crookes tube, called a Puluj tube, energized with an induction coil and Grove batteries. The length of exposure was fifteen to twenty minutes. The photographic plate holder is on the table, with the fractured arm resting on it.

This was a Puluj tube, differing from other Crookes tubes in that it had across the interior, in an oblique position, a piece of mica painted with a fluorescent material. As the cathode rays fell upon the phosphorescent salts, a large quantity of x-rays was produced. With an exposure of only twenty minutes, as Professor Frost pointed out, it was possible for him to obtain a clear roentgenogram of a broken arm. The apparatus at his disposal was probably the best in America. He also had the cooperation of Mr. H. H. Langill, the local photographer.

Still another communication in this issue of *Science* was by Prof. Arthur W. Goodspeed of the University of Pennsylvania. A direct quotation serves to establish the time relationship of his experiments. Under date of Feb. 8, he wrote:

"During the past week, experiments have been in progress in the Physical Laboratory of the University of Pennsylvania on the Röntgen phenomena. Impressions of several surgical cases, including deformed fingers, fractures, etc., have been successfully produced."

But while Goodspeed evidently obtained x-ray pictures of pathologic conditions during the week preceding Feb. 8, 1896, he did not publish these at this early date, nor did he mention any specific instance. Incidentally it was he who suggested the term "radiography."

Many articles appeared in subsequent issues of *Science* and in other periodicals, but none, so far as it is possible to ascertain, fixed the date of photographing an actual pathological lesion.

An account of his early application of roentgen rays to a field in which it was to

become a commonplace was furnished by Professor Frost to the *Dartmouth Alumni Magazine* nearly thirty-five years later. It appeared in the April 1930 issue. Professor Frost made no claim to priority in the taking of medical roentgenograms in this country, but the editor assumed that responsibility, and in the light of the present writer's investigations, would seem to be warranted in that assumption. Frost's account of the incident reads:

> "A Hanover boy, Eddie McCarthy, had broken the ulna of his forearm on January 19 and Dr. Gilman D. Frost brought him to the laboratory for a test by the photographic method. We secured quite a satisfactory photograph on February 3, as was mentioned in my article in *Science*. This was presumably one of the earliest photographs of a fracture taken in America."

In the Spring of 1896 many roentgenograms were made in the Dartmouth laboratory, and some of these are reproduced in Professor Frost's article, along with that showing the fractured ulna. One shows a metal splinter in the forearm, another a bullet in the knee, and still another a fracture of the humerus.

Six years after Frost's contribution to the *Alumni Magazine*, Arthur Fairbanks, writing in the same publication (February 1936) of Frost's contributions to astronomy and to humane living, said:

> "His brother, Dr. Gilman D. Frost, brought him a patient with a broken bone in the arm, and on February 3 he obtained the first x-ray photograph of a fractured bone made in America."

A photograph of the event itself accompanied this account. It was in 1936, also, that the present writer, returning to his alma mater for a brief holiday, encountered Dr. Gilman D. Frost on the Dartmouth campus carrying an envelope containing this same photograph and there heard the story of the first x-ray picture of a broken arm, taken forty years earlier.

In an effort to substantiate Professor Frost's priority in the field of roentgen diagnosis, a careful search of the American literature has been made, with the results recorded above. In the course of these investigations, Dr. Archibald Malloch, li-

Fig. 2. The first roentgenogram of a pathological condition taken in America, Feb. 3, 1896. The fracture lines of the radius and ulna are distinctly shown.

brarian of the New York Academy of Medicine, was consulted. In a personal communication, dated March 13, 1945, he wrote: "We have found no positive statement that anyone in the United States before Edwin B. Frost, on Feb. 3, 1896, took an x-ray picture of a fractured bone." Dr. Otto Glasser, radiation research physicist of the Cleveland Clinic, whose aid was also enlisted, stated that he had been unable to ascertain who was the first in America to take an x-ray picture of a pathological condition. An editorial appearing in the *Journal of the American Medical Association*, April 21, 1945, refers to the claim made "by some, that William J. Morton was the first American physician to make x-ray pictures," but no

dates are given. It would therefore seem that the credit of obtaining the first roentgenogram of a pathological lesion in America belongs to Prof. Edwin B. Frost, the date being established as Feb. 3, 1896.

NOTE: Grateful acknowledgement for their co-operation is due Dr. Otto Glasser, radiation physicist at the Cleveland Clinic; Dr. Archibald Malloch, librarian, New York Academy of Medicine; Dr. Nathaniel T. Goodrich, librarian, Dartmouth College Library; Mr. Charles E. Widmayer, Editor of the Dartmouth Alumni Magazine; and Professor A. B. Meservey, physicist, Dartmouth College.

The roentgenogram of the fractured arm was kindly loaned by Professor Meservey. The original negative, as well as the apparatus used by Frost, is in the museum of the Wilder Laboratory of Physical Sciences at Dartmouth College. The photograph of the procedure itself was the gift of Dr. Gilman D. Frost to the writer, who would here take the opportunity of paying his tribute to that great teacher of practical medicine, one whose instruction was based not on mere pedagogical formulae but on the ripe judgment that comes only with experience.

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1895  1945

RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

Vol. 45 DECEMBER 1945 No. 6

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RADIOLOGY

A MONTHLY PUBLICATION DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

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RADIOLOGY is entered as second class matter at Syracuse, New York, and Easton, Penna., under the Act of August 24, 1912, and accepted November 24, 1934. RADIOLOGY is published by the Radiological Society of North America as its official Journal. Subscription rate $6.00 per annum. Canadian and foreign postage, $1.00 additional. Single copies, 75¢ each. All correspondence relative to business matters connected with the Radiological Society of North America and RADIOLOGY, or remittance for non-member subscriptions, should be made payable to the Radiological Society of North America and should be addressed to the SECRETARY-TREASURER, DONALD S. CHILDS, M.D., 607 MEDICAL ARTS BUILDING, SYRACUSE 2, NEW YORK. In requesting change of address, both the old and the new address should be given.

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The Teaching of Radiology[1]

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THE OCCASION of the present gathering, the first of the Leo Rigler Lectures, may well be considered as an important milestone marking a new and forward-looking step in the progress of radiology as a full-fledged specialty. Certainly no thoughts here expressed, no mere vocal statements made by any of us, will materially alter the present or future stature of that vigorously growing branch of medical endeavor. It is, however, important that the University of Minnesota has established an annual lectureship in the name of an outstandingly energetic and stimulating teacher of radiology, even now at the height of his effectiveness. This act, conceived and accomplished by his former students, his colleagues, other friends, and the splendid institution of which he is a part, must be looked upon as a rare compliment to Leo Rigler's accomplishments, as well as a formal acknowledgment of the far-reaching importance and future promise of the branch of medicine which he has chosen. This public expression of encouragement and confidence will not pass unheeded—will lead to greater and more sustained progress in the advancement of radiology.

In years to come, when succeeding lecturers take up the theme which will run through the many chapters yet to be written for this series, rich tribute will be paid to the fine personal qualities and the sound professional accomplishments of the man whose impact upon his associates locally and throughout the medical world stimulated the creation of the Rigler lectureship. Upon this, the founders' day gathering, rather let us look into the future of the medical specialty which has attracted to its service a man of Dr. Rigler's stamp, to determine if we can whether his devotion to that specialty is likely to be justified—whether succeeding waves of medical students will be well advised to seek thorough preparation in the radiological approach to the problems of medical practice.

Forty-nine years to the month, or at least to the season, after Wilhelm Conrad Röntgen's momentous description of a new form of rays capable of penetrating many substances opaque to visible light, this enormously important contribution to present-day medical practice requires no exposition before physicians or patients. Seldom has any single addition to the sum of human knowledge been exploited so rapidly, so extensively, or so usefully. In our time we are privileged to observe that the rate of acceleration at which medical radiology is expanding continues to in-

[1] From the Department of Roentgenology, University of Michigan. Delivered as the first of the Leo G. Rigler Lectures in Radiology, University of Minnesota, Dec. 9, 1944. For the institution of this lectureship, see Radiology 44: 297, March 1945.

crease. There is as yet no indication that the long-range benefits to be derived from Röntgen's truly great discovery have been fully realized.

The extreme speed with which every innovation involving the diagnostic or therapeutic utilization of radiological principles is absorbed into daily medical practice renders further advance progressively more difficult. The rising load of clinical duties constantly threatens to submerge teaching activities and research by the very persons who are most able and anxious to indulge in such pursuits. Practical and academic duties are so intimately interwoven in the radiological divisions of all American medical schools that neither can be emphasized without detriment to the other. Since the local markets for routine clinical output are so genuinely eager, teaching and research activities are more often than not conducted as a side line of lesser importance.

At the University of Michigan, where actual conditions are well known to me by first-hand contact, utilization of the clinical services offered by the Department of Roentgenology has increased steadily over a period of fourteen years until annual patient visits in this division exceed total patient registrations by a considerable margin 56,000 versus 30,000. Apart from the photofluorographic chest survey of all patients at the registration counter of the hospital, eight of every ten persons who apply for medical advice or care find themselves referred for some form of radiological service within three months after registering at the clinic. If nothing beyond routine clinical duties were required of the staff in radiology, the aggregate load of such work would amply justify its existence. The maintenance and operation of the specialized apparatus required, administration of the affairs of the professional and non-professional staff members, the handling of patients, and the preparation of suitable reports to be filed in clinical case histories constitute a sizable effort. In addition, the department carries on a considerable variety of teaching efforts at undergraduate, graduate, and postgraduate levels. As best it can, the staff has indulged in clinical investigations within its scope. Regardless of all theoretical concepts concerning the relative importance of these various activities, it is the plain truth that the accomplishments of the department are measured primarily by the efficiency with which routine clinical service is provided, not by the quality of instruction offered nor by the quantity or excellence of research. This state of affairs in one American educational institution will serve as a fair sample of the situation at large.

In some of the outstanding medical schools of the country, the high market values attainable by radiologists of ability have been responsible for the penetration of the profit motive into academic radiology. It is variously argued that this is a necessary evil—necessary if the best talent is to be lured into the teaching field—or that it constitutes a genuine virtue—the virtue of preserving the truest possible replica of the conditions which actually prevail in radiological practice throughout the specialty at large. Whatever the justification offered, it can scarcely be true that further emphasis upon the daily application of already acquired knowledge is either necessary or desirable from the point of view of universities, whose avowed reasons for existence are to teach students and to foster investigation.

In many institutions, the University of Minnesota being one, radiology, when added to the medical curriculum and to the clinical services of the teaching hospital, was grafted onto one of the existing clinical divisions, usually internal medicine or surgery. The results of this practice have been multilateral. On the one hand, medical school radiologists serving on this basis have been spared much in the way of nonproductive administrative duties, while on the other hand, the fruits to be derived from administrative endeavors, had they been directed toward the specific welfare of radiology, have been denied. Radiology has reached a stage in the course of its

development which easily justifies departmental autonomy. Its interests, clinical, educational, and in the matter of scholarly achievement, are sufficiently distinctive and extensive to warrant a full voice in medical school affairs and independent choice of policy. Since radiological procedures always have been able to support themselves financially, radiology does not need budgetary support from a parent department. Both the University of Michigan and the University of Minnesota now recognize radiology as a full-fledged medical school department and the same is true for several other institutions. Wherever this plan has been adopted, the teaching of radiology has flourished.

Whether radiology is accorded departmental status or is relegated to a position of secondary importance in the organization of medical schools, the rapidly expanding application of radiological principles in the practice of medicine must impress us with the desirability of expanding our teaching in this field. It is highly desirable that any move in this direction shall be designed to benefit *all* students, not merely those who have expressed a desire to devote themselves to this branch of medicine as specialists. Unlike specialists in most other clinical branches, radiologists utilize skills and instruments which have an almost universal application. Today it is quite impossible for any physician to disregard the radiological considerations which figure so importantly in the diagnosis or treatment of almost every disease. The undergraduate study of medicine is rendered more effective and more attractive by an understanding of the principles upon which the specialty of radiology is based. One cannot teach the x-ray signs of disease, the results to be expected of radiation therapy, as a subject totally apart from other diagnostic and therapeutic considerations. To be appreciated properly, the benefits to be derived from radiological procedures must be interwoven inextricably in the student's mind with his concept of the basic sciences and the preclinical subjects, as well as his understanding of disease as it is encountered in the practice of medicine. At Michigan it is our aim to equip every physician who graduates with a sufficient understanding of the possibilities, the limitations, and the shortcomings of radiology to permit him to evaluate the radiological services which will be rendered to his patients in future years—to teach him to use such services to the fullest advantage. While we do presume to train a limited number of graduate students who desire to devote their full energies to our specialty, we consider that the impressions which we leave upon the entire undergraduate student body represent our most important contribution to the University, routine clinical performance not excluded.

There is a place for radiology in the general plan of undergraduate medical education, a place for the presentation of the subject as an academic entity rather than a highly valued, though strictly utilitarian, handmaiden to the various clinical divisions. An understanding of the basic principles upon which the useful medical applications of radiant energy depend is fully as important to the intelligent practice of medicine as are the time-honored drills in the technics of bacteriology, biochemistry, and pathology. As medicine is practised today, the sum total of the evidences of disease made available through the employment of x-rays is certainly no less voluminous or helpful than the information which is derived from the application of those "classical" sciences. Few indeed are the physicians who find it necessary or desirable to carry out in person the exacting laboratory methods of Kjeldahl distillation, the recovery in pure culture of pathogenic organisms, or the sectioning, mounting, and histologic study of tissues, in order to serve their patients. It is argued with entire propriety, however, that as students physicians must have familiarized themselves with the methods and the scope of content as well as the philosophy of the various subjects which, moulded into an amazingly intricate whole, constitute the science of medicine. With the passage of busy years, replete with

The development of separate quarters for the non-clinical activities to be started would represent an initial expenditure of $40,000 to $50,000 for equipment and building renovations and an annual addition to the budget of $10,000 to $15,000 for machinists' salaries and materials.

If, to continue with this hypothetical situation, the Dean were to inquire where the necessary funds were to be found, my answer would be prompt and emphatic. I would recommend an initial loan of $50,000 by the University for capital outlay, secured by the allocation of 50 per cent of the net proceeds of clinical activities of the department for a period of five years. Thereafter the added operating expense would be covered by 25 per cent of current clinical proceeds earmarked for that purpose. It is my firm belief that this proposal is sound financially as well as academically. Able physicians, broadly trained in radiology and imbued with the ambition to follow a career of academic medicine, would find the fullest outlet for their energies in such surroundings. Medical students at Michigan would be exposed in the broadest fashion to the possibilities offered by radiology. The department's clinical performance would be enhanced by new advances in radiological knowledge effected by its own staff and students. The entire venture would be self-sustaining.

It is not to be expected that sweeping changes such as those here suggested will come about spontaneously, nor that they will be forced upon teaching departments of radiology without insistent demands from within. So long as students, faculties at large, and the alumni of medical schools are content to have radiology exist primarily as a hospital service division, and until radiologists in teaching positions a[illegible] aroused and committed to a program whi[illegible] offers full-scale performance, it is idle [illegible] presume that any such development w[illegible] come to pass.

It goes without saying that the pur[illegible] clinical aspects of radiological teachi[illegible] should include the training of a few w[illegible] chosen candidates for specialization. Th[illegible] can be done under existing conditions; [illegible] is being accomplished creditably at t[illegible] present time. Radiology at many instit[illegible] tions now offers postgraduate or continu[illegible] tion study of acceptable quality, and t[illegible] value of inter-departmental clinical conf[illegible] ences is thoroughly appreciated by [illegible] participating divisions. Primary emphasis upon the undergraduate responsibilities of radiology in no degree threatens the scope or the quality of these activities; it insures rather their continuation at a decidedly higher level.

With the courteous indulgence of a most sympathetic jury I have had my day in court. I have been permitted to air my own personal ambitions for academic radiology and have outlined a dream regarding a point of departure for bigger and better things in our specialty. This evening's dissertation must be considered in the light of a preliminary hearing to which other Rigler lecturers may be expected to add pleas variously modifying the views here offered by one individual. I am extremely grateful to have been accorded this opportunity to christen the Rigler lectures, much as a new ship is committed to its element, with the fervent wish for smooth sailing and a proud record of achievement in the lives of men.

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The Clinical Significance of Deformity of the Cecum in Amebiasis[1]

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Amebiasis is defined as the presence of the *Endamoeba histolytica* in the wall of the large intestine or in other tissues. The clinical diagnosis of the disease depends primarily upon the demonstration of the organism in one or another of its forms in the stools of the patient. Vallarino (1925) showed that in some cases lesions were produced in the colon which were demonstrable by roentgen methods. Weber (1933) and Bell (1936) demonstrated deformity and shrinking of the cecum in a number of cases of amebiasis. The purpose of this paper is to present a series of cases which confirms the observations of Weber and of Bell and which emphasizes the practical value of recognition of the cecal deformity. No attempt will be made to discuss details of symptoms, treatment, or other aspects of the disease.

INCIDENCE OF AMEBIASIS

Competent observers believe that amebiasis is not uncommon among the people of the United States. Craig (1940) stated: "In this country numerous surveys have shown that the incidence of the infection varies from one per cent in some localities to as high as 30 to 40 per cent in others. The incidence in 69,000 individuals surveyed in the United States and collected by the writer has been a little over 10 per cent. It may be conservatively stated that from 5 to 10 per cent of the people of this country harbor the parasite and that the percentage is higher in the south than in the north." Craig and Faust (1943) estimated that 13,000,000 people in this country are infected.

In a series of 202 necropsies in accident cases in New Orleans, Faust found *E. histolyticae* present in the fecal content of the large intestine in 13 (6.4 per cent) and demonstrated amebic lesions in the mucosa in 7.

SYMPTOMS

The *E. histolytica* in the large intestine may or may not cause symptoms. Amebic dysentery, *i.e.*, amebiasis with severe diarrhea, occurs in only a small number of patients with amebiasis. D'Antoni (1942) stated that in 1939 amebic dysentery was reported in 2,981 individuals in 33 states with a total population of 107,355,000. "Although these reports probably do not represent the actual number of cases, it is significant that only a small proportion of patients infected with E. histolytica showed dysentery." D'Antoni believed the non-dysentery cases to be the major problem.

The commonest symptoms in the non-dysentery cases (Craig and Faust) are constipation, attacks of slight diarrhea, underweight, colicky pains in the lower abdomen or right lower quadrant, and pains in the head, back, and extremities. The symptoms (D'Antoni) may simulate cholecystitis, peptic ulcer, or appendicitis. The presenting symptom in one of our patients was persistent fever of several months' duration. Fever with leukocytosis was associated with other symptoms in several of our cases. The patients without symptoms are called carriers.

PATHOLOGY

The primary lesion of amebiasis is an ulcer which involves the mucosa, which may extend into the submucosa but which does not penetrate the tunica muscularis James (1928) described two types of ulcer,

[1] From the Departments of Radiology of the Presbyterian Hospital and of the College of Physicians and Surgeons, Columbia University, New York City. Read before the Joint Meeting of the American Roentgen Ray Society and the Radiological Society of North America, Chicago, Ill., Sept. 24–29, 1944.

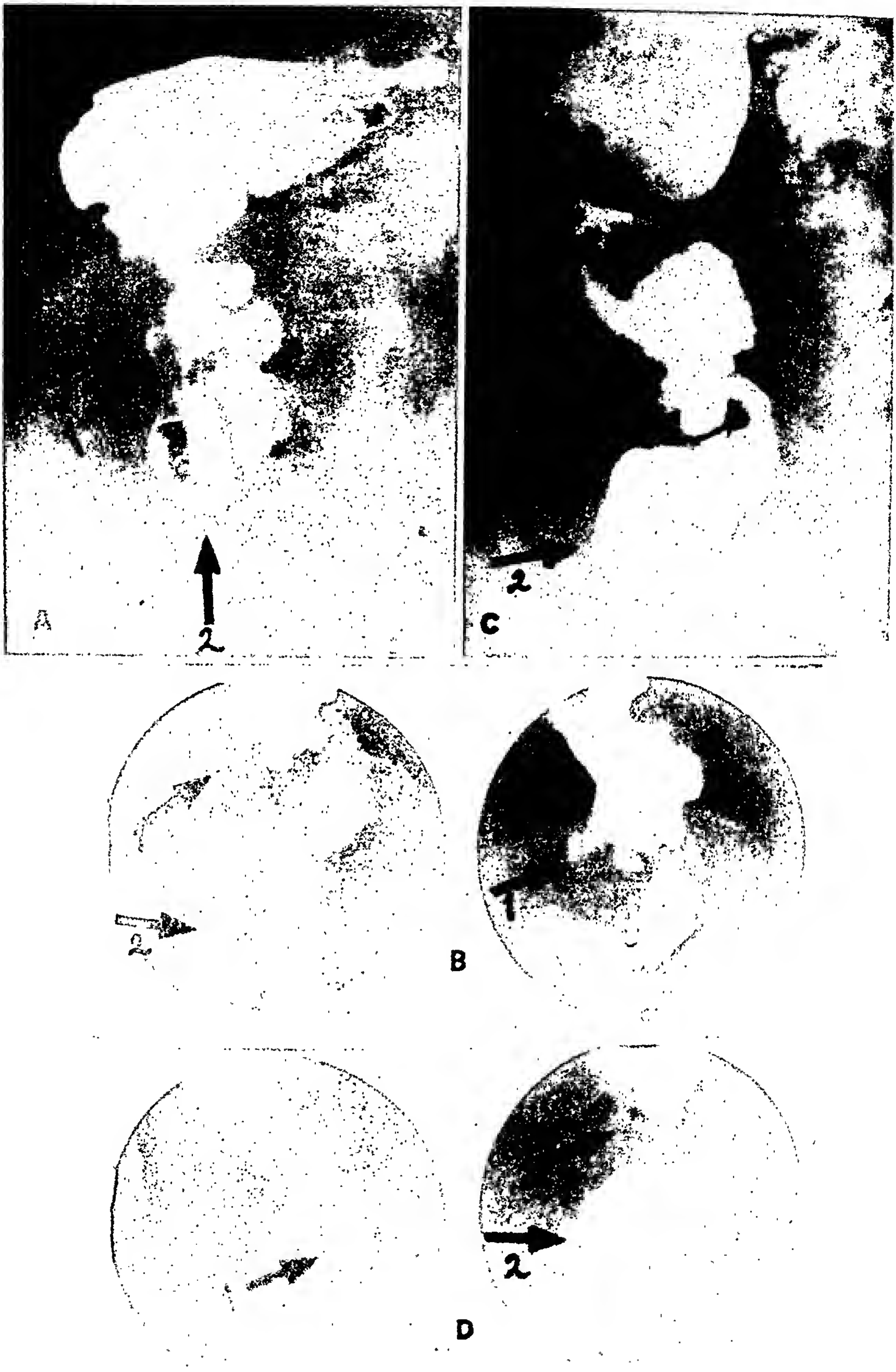

Fig. 1. Amebiasis of the Cecum with Fever as the Presenting Symptom and with No Change after Treatment.
For history, see opposite page.

(1) flask-shaped or undermined and (2) superficial, spreading over the surface of the mucosa; early lesions may be so small that they cannot be seen with the naked eye. In autopsy material obtained from 7 individuals who were accidentally killed in New Orleans, Faust (1941) found three types of ulcers: (1) pin-point ulceration, which is the initial lesion, (2) shallow, crater-like ulcers, and (3) extensive, shallow denudation of the mucosa. None of these ulcers extended below the muscularis mucosae and none showed evidence of bacterial invasion or of repair. However, Faust (1944) stated that the amebic lesion in chronic amebiasis is usually secondarily infected with bacteria.

SITE OF LESIONS IN THE LARGE INTESTINE

Amebic lesions may be present throughout the entire large intestine. They are likely to be most numerous or may be present only in the cecum and ascending colon and in the sigmoid and rectum. The ileum is rarely involved. Clark (1925) reported 186 postmortem cases in Panama, of which 159 died of amebiasis, including 95 instances of liver abscess. About 60 per cent of this series had lesions throughout the large intestine. In the 40 per cent with a local distribution the sites of the lesions in order of frequency were: (1) cecum and ascending colon, (2) sigmoid and rectum, (3) appendix. The cecum was involved either alone or with other portions of the large intestine in 88.7 per cent.

In 202 accident cases which came to necropsy in New Orleans, Faust (1941) found amebae in the intestinal contents in 13. The organisms were present in the cecum in 11 and the actual lesions were found in the mucous membrane in 7 cases, of which the cecum was involved in 6 and the ileum with the cecum in only one. In one instance lesions were present only in the cecum. None of the ulcers extended below the muscularis mucosae.

The ileum is rarely the site of amebic lesions, as suggested above. Clark (1925) does not mention involvement of the ileum in his series of 186 necropsy cases, most of which were severely infected. Craig (1934) stated that he had records of only 6 cases in which ulcerations were found above the ileocecal valve. However, Faust (1941) quoted Clark as having found the ileum involved in 9 (4.5 per cent) and the ileocecal valve in 4 (2.0 per cent) of 198 necropsy cases in Panama. Faust also quoted Connell as having found lesions in the ileum in 4 and on the ileocecal valve in one of 36 necropsy cases in New Orleans.

RADIOLOGY OF AMEBIASIS

Vallarino (1925) described "filling defects" in the large intestine associated with

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Fig. 1. Case History.

A 46-year-old woman (Unit No. 715608) was admitted for study because of fever and weakness of more than three months' duration. Before admission she had seen twenty-six doctors, according to her statement. No cause for the continued fever has been found. The blood cell count showed: Hgb. 68 per cent, R.B.C. 3.7 million, W.B.C. 16,000, neutrophils 82 per cent. The liver was slightly enlarged. The blood phosphatase was 19.2 Bodansky units. The serum protein was 5.7. There was no history of diarrhea or abdominal pain. The patient's twenty-seventh doctor suspected amebiasis, asked for x-ray examination to find out whether the cecum was abnormal, and began a search for amebae. A small intestine study, Aug. 5, 1943, disclosed a slow transit time in the small intestine. The barium did not reach the cecum until nearly seven hours, although the patient was given food at four hours.

Fig. 1, *A*, is a spot film without pressure, which shows the small deformed cecum (1) and a coil of ileum (2) below the cecum, which could not be separated from the cecum. Moderate tenderness on pressure was present. The ascending colon is constricted just above the ileocecal valve.

B shows pressure films of the cecal tip (1) and the loop of ileum (2), which could not be straightened out by pressure. The ileum is not narrowed or constricted. Its mucosal folds appear obliterated or indistinct. These findings were considered consistent with amebiasis. Amebae were found in the stools. Emetine therapy was followed by disappearance of the fever, the patient's subjective condition improved, and the stools became negative.

C is a spot film of the right lower quadrant, Oct. 13, 1943, showing a change in the shape of the cecal tip, but little, if any, change in its size took place.

D shows pressure films taken at the same time showing the same immovable coil of ileum (2) below the cecum (1), which is slightly deformed by pressure. The mucosal pattern of the terminal ileum is now normal. The patient was feeling very well and had a ravenous appetite. It would be interesting to know whether the abnormal mucosal pattern of the ileum in *B* was due to amebic lesions in the mucosa or to edema resulting from hypoproteinemia and other nutritional disorders. This patient had traveled extensively in the United States but never beyond its continental limits.

TABLE I: SUMMARY OF MATERIAL

Total number of patients with suspected or proved amebiasis		
With amebae in stools		107
With no amebae demonstrated in stools on one or more examinations		8
(One had superficial ulcers in the cecum on pathologic examination)		
With inadequate information concerning stools		4
(One was proved by pathologic examination to have amebiasis)		
Number of patients having x-ray examination with barium		
Barium by rectum		18
Barium by mouth		27
Both methods		22
Deformed cecum		
With positive stools		21
With negative stools		7
(One had superficial ulcers in the cecum on pathologic examination)		
With inadequate information about stools		2
X-ray examination of patients with positive stools		
No demonstrable abnormality		33
Deformed cecum		21
Other abnormalities of the colon		4
X-ray examination of patients with negative stools or inadequate information about stools		
No abnormality		0
Deformed cecum with negative stools		7
(One had superficial ulcers in the cecum on pathologic examination)		
Deformed cecum with inadequate information about stools		2
X-ray examination of patients with diarrhea		
Deformed cecum		18
X-ray examination of patients with abdominal symptoms but no diarrhea		
Deformed cecum		3
X-ray examination of patients with no diarrhea or abdominal pain		
Deformed cecum		4
(This included one case with fever as the presenting symptom)		
X-ray examination of patients with inadequate information about abdominal symptoms		
Deformed cecum		5
(These were private patients whose complete records were not available)		
Amebiasis mentioned in x-ray report, with deformed cecum		
Amebiasis mentioned in x-ray report, with deformed transverse colon		
Wrong interpretation of deformed cecum		
Called tuberculosis		1
Called carcinoma		1
Abnormality of cecum described but not interpreted		
Abnormality of cecum present but not noted at time of examination		3
With positive stools		1
With negative stools and rectal stricture		
Lesions distal to cecum		2
Deformed transverse colon alone with positive stools		1
Deformed transverse, ascending colon and cecum with positive stools		1
Rectal stricture alone, with positive stools		1
Rectal stricture with deformed cecum, negative stools		
No x-ray examination		49
With positive stools		28
With positive stools and diarrhea		6
With positive stools and abdominal symptoms without diarrhea		15
With positive stools and no abdominal symptoms		2
With inadequate information about stools		1
With negative stools		
No recorded abdominal symptoms referable to the intestine		31
With positive stools		
With abdominal symptoms		61
Diarrhea with or without blood	56	
Positive stools	3	
Negative stools	2	
Inadequate information regarding stools		
(One proved to be amebiasis by pathologic demonstration of lesions in cecum)		15
Abdominal symptoms without diarrhea	14	
Positive stools	1	
Inadequate information regarding stools		

Inadequate information regarding symptoms			9
With negative stools and with cecal deformity		5	
With positive stools		3	
No x-ray examination	2		
X-ray examination with no cecal deformity	1		
With inadequate information regarding stools		1	
Cases having pathologic examination			5
Autopsy following pneumonia, positive stools, no x-ray examination, ulcers in ascending and transverse colon, cecum negative		1	
Autopsy following Hodgkin's disease, inadequate information about stools, x-ray examination with negative cecum, shallow ulcers in cecum, ascending colon and rectum		1	
Liver abscess with positive stools and no x-ray examination		1	
Liver abscess with positive stools, x-ray examination, barium by mouth, negative cecum		1	
Resection of cecum following erroneous diagnosis of carcinoma, negative stools. X-ray examination showed deformed cecum. Pathologic examination showed shallow ulcers in the cecum and proximal ascending colon but none in the ileum		1	
Travel record			
No record of travel far from New York area			17
Travel in the U. S. including Chicago 1933			16
Travel outside the U. S. (includes 2 who also had been in Chicago)			76
Coming from or travel to Latin America		44	
Travel occurred less than 10 years before examination		65	
Travel occurred more than 10 years before examination		11	
Inadequate information about travel			10
Sex ratio, total number			119
Males		81	
Females		38	
Age incidence			119
11–20 years		8	
21–30 years		22	
31–40 years		38	
41–50 years		24	
51–60 years		20	
61–70 years		4	
71–80 years		3	

amebiasis, which diminished following antiamebic treatment. They were more numerous in the cecum and ascending colon and in the sigmoid, although they were demonstrated in other portions of the colon as well.

Weber (1933) described the following changes on roentgen examination of the cecum in amebiasis: suppression of haustral markings, shortening and narrowing, and abnormal patency of the ileocecal valve.

Bell (1936) reported 7 cases of amebiasis with small deformed cecums. This deformity he believed should be considered as highly suggestive of this condition, though it might be simulated by tuberculosis limited to the cecum or by carcinoma. In two subsequent publications he confirmed these observations and reported additional cases. He also reported personal communications from deLorimier, from Reeves, and from King, who had observed similar cecal deformities in this condition.

MATERIAL

Several cases have been encountered at the Presbyterian Hospital in which the first suggestion that the patient might have amebiasis came from the demonstration of a deformed cecum. This led to a review of all of the available cases in which amebiasis was either proved or thought probably to be present. This material is reviewed and summarized in Table I. More than twice as many men as women were included in the group. The youngest patient was thirteen and the oldest seventy-eight, but the majority were between twenty and fifty years old, with the greatest incidence in the fourth decade.

Of the 119 patients whose records were reviewed, 107 had the *E. histolytica* in the stools. In one case with inadequate information about the stools, ulcers were demonstrated in the cecum and ascending colon with amebae in the tissues. Amebiasis, therefore, was proved to be present in 108 (90 per cent) of the 119 cases.

The stool examination in the vast majority of cases was done by a competent technician of many years' experience at the Presbyterian Hospital. A very few had a history of positive stools which was considered reliable.

No attempt was made to correlate the record of negative stools with the number of stool examinations. One examination of the stool (Craig and Faust) will disclose not more than one-third of the infections. Linders (quoted by Craig and Faust) believed that ten to twelve examinations are necessary to pick up approximately all the infections. Faust found that an unconcentrated film examination from three or four specimens obtained on alternate days and one zinc sulfate centrifugal flotation procedure gave a high percentage of accuracy. Three of the 8 patients whose stools are recorded as negative had only one examination, which is obviously insufficient. Information concerning the presence or absence of amebae in the stool was classed as inadequate if no search for these organisms was made, as occurred in 4 cases.

The roentgen examinations were done by various members of the staff, of varying degrees of experience.

It is of interest that 74 of the 119 were private patients, while 45 came from the wards or the Vanderbilt Clinic. All those who had been outside the continental limits were classed as having traveled outside the United States whether they were citizens who had temporarily visited or whether they were born in other countries. A number of the patients came from Latin America for medical care. A few had been in the Orient, North Africa, and Europe. Because it seemed likely that recent travel would be more significant from the epidemiological standpoint, the patients were divided into two groups; those who had been outside the United States (1) less than ten years and (2) more than ten years before the examination. The first group numbered 65 and included those who came to this country for medical care. In the second group of 11 individuals, the foreign travel is probably of considerably less importance. One patient was born in Switzerland and came to this country in childhood. He had to be included in the second group, although undoubtedly he acquired his infection here. As far as could be determined, 17 patients had not been away from the eastern seaboard in the New York area. Six of the patients who had traveled within the United States undoubtedly were infected in Chicago in 1933.

Sixty-one, more than half of the 119 patients, had diarrhea, and 15 had abdominal symptoms, usually pain, without diarrhea. Forty-nine of the 52 patients who had no x-ray examination had positive stools. Twenty-eight of the 49 also had diarrhea, while 6 had pain without diarrhea, and 15 had no diarrhea or abdominal symptoms ordinarily attributed to amebiasis. Casual common complaints of gas and constipation were not recorded as abdominal symptoms for this purpose. In this last group of 15 cases, the reason why the successful search for amebae was undertaken is not clear from the records. It is evident that diarrhea is the symptom most likely to raise the question of amebiasis in a general hospital in the temperate zone and to lead to a diagnosis without x-ray examination.

Thirty-three of the 61 patients with diarrhea had x-ray examination of the colon and 18 of them had a deformed cecum. Nine of the 15 patients with abdominal pain without diarrhea had x-ray examination of the colon and 3 had a deformed cecum. Eighteen of the 34 patients with no recorded intestinal symptoms had colon examinations and 4 had a deformed cecum; this group included an interesting case with fever as the presenting symptom (*Fig. 1*). Information concerning abdominal symptoms was inadequate in 9 cases, 7 of which had x-ray examination and 5 had a deformed cecum; one of the patients so classified died of Hodgkin's disease, and amebic ulcers were found at necropsy in the cecum, ascending colon, and rectum.

DISCUSSION

The analysis of this series of cases indicates that deformity of the cecum was

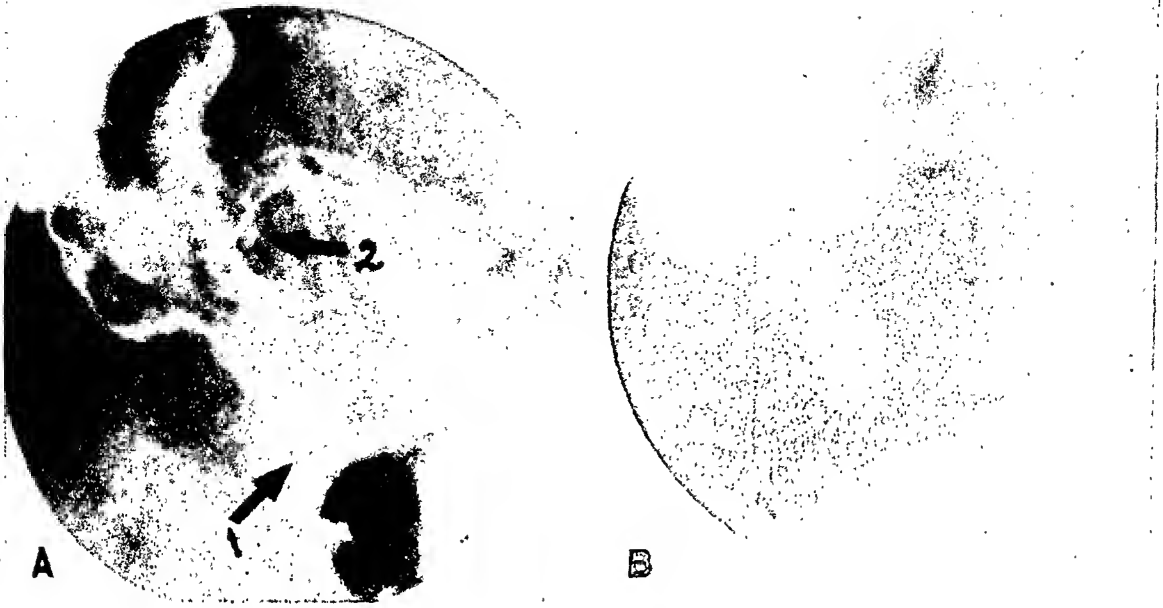

Fig. 2. Probable but Unproved Amebiasis of the Cecum Interpreted as Carcinoma, with Resection.

A man (Unit No. 587219) 53 years old, who was born in Switzerland but who had been in the United States since the age of 12, was admitted in 1938 for study. He complained of nausea of eight months' duration, weakness, fatigability, loss of 17 lb. in about three months, fever, and an indefinite sense of discomfort in the right lower quadrant. During 1908 he had several bouts of diarrhea, with "gas pains" in the right lower quadrant. In 1912 the attacks began again and continued intermittently until 1920, when they spontaneously ceased. Appendectomy was done without relief. On admission the liver was enlarged. The erythrocyte sedimentation rate was 92. The fever went up as high as 102.5°. Two stools showed positive tests for occult blood. One stool after a cathartic was examined for *Endamoeba histolytica* and none was found. X-ray examination disclosed a short deformed cecal shadow which was interpreted as "probably carcinoma with a remote possibility of tuberculosis." *A* and *B* are two pressure films of the cecum with an apparently normal terminal ileum. (Arrows: 1 is cecal tip; 2 is ileocecal junction.)

At operation, a lesion was found opposite the ileocecal valve which was not as large as anticipated nor as hard as carcinoma. No evidence of an inflammatory reaction could be seen. Ileocecal resection was done. Pathologic examination showed the serosa to be smooth and glistening. The wall of the cecum was thickened, varying from 0.4 cm. to 1.5 cm. in width, with fibrous tissue in its thickest portion. The base of the cecum was 5 cm. in width, tapering to a finger-like projection 2 cm. in width. The cecal mucosa was flattened, edematous, dull, immobile, and showed 8 shallow ulcers, none of which extended deeper than the muscularis mucosae. In the lower part of the ascending colon was a similar diamond-shaped ulcer measuring 2 × 1 cm. The pathologist described these ulcers as not dissimilar to those of amebiasis, but no amebae could be demonstrated in the tissues. There was no evidence of carcinoma.

After operation the patient continued to run a fever, with occasional chills, with a leukocytosis up to 16,000, and with negative blood cultures. No explanation could be found. On the sixteenth postoperative day emetine therapy was started. Six days later the temperature suddenly became normal and the patient promptly got well. Two more stool examinations failed to disclose amebae. The clinicians thought the response to emetine suggested amebic hepatitis or possibly amebic abscess of the liver.

demonstrated in 30 of 67 patients having colon examination by barium methods. Cecal deformity occurred about five times as frequently in association with diarrhea and abdominal symptoms attributable to the intestine as with no such intestinal symptoms. The symptomless carriers are much less likely to have a deformed cecum than are those patients in whom the disease is severe enough to cause symptoms.

Twenty-one (36 per cent) of the 58 patients with the *E. histolytica* demonstrated in the stools had a deformed cecum. If this proportion holds, presumably 17 or 18 of the 49 patients with positive stools who had no x-ray examination of the large intestine would have shown deformity of the cecum if the examination had been done. Another patient with a deformed cecum had ulcers in the mucosa of the resected cecum and ascending colon, but amebae could not be demonstrated in the ulcers; postoperative fever and leukocytosis continued for twenty-two days, ceasing on the sixth day after treatment with emetine was begun (Fig. 2). In addition, 2 other patients with normal appearing cecums had deformity of the transverse colon and an-

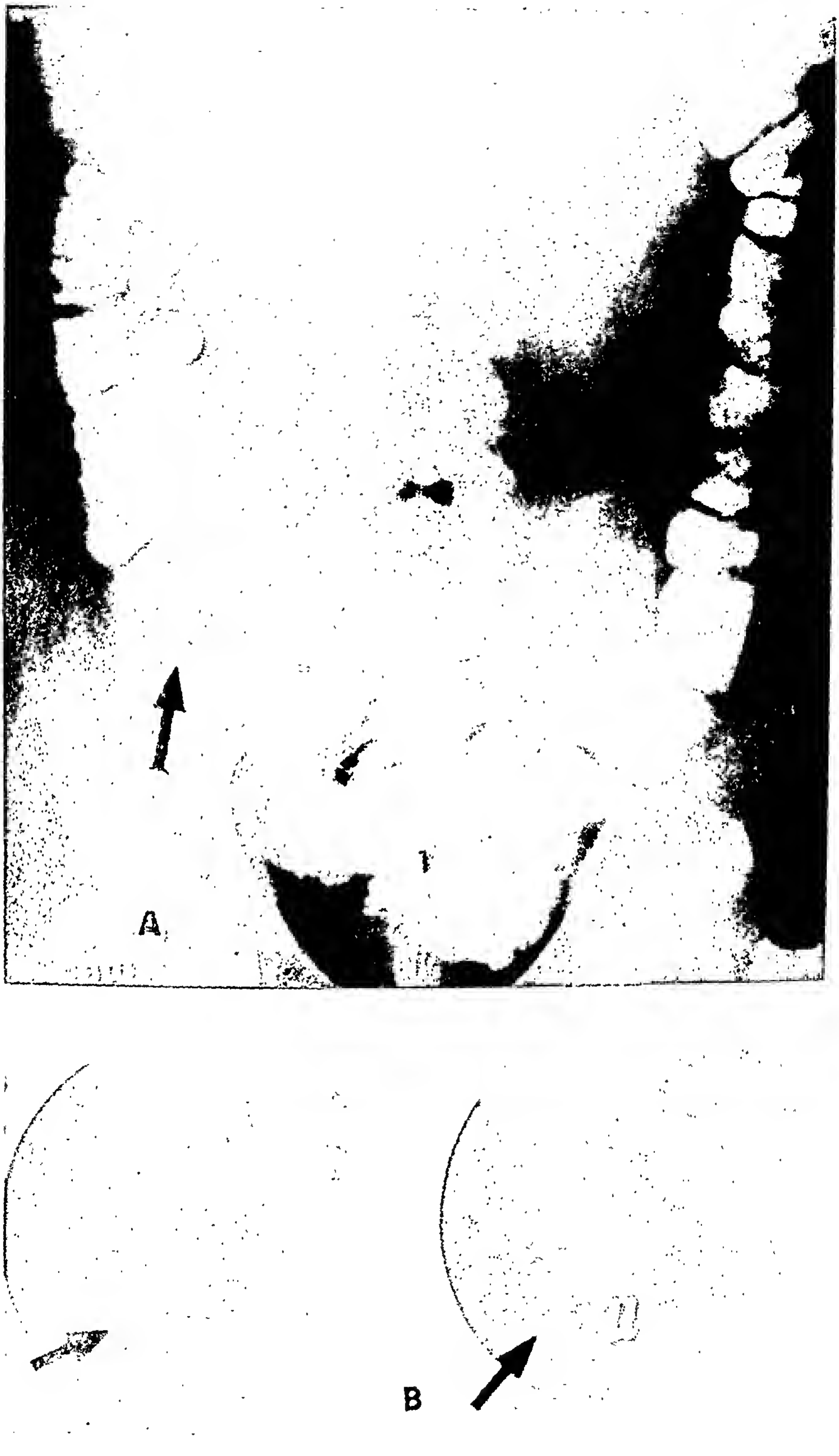

Fig. 3, A and B. Amebiasis of the Cecum with Improvement Following Oral Medication. See Fig. 3, C, for case history.

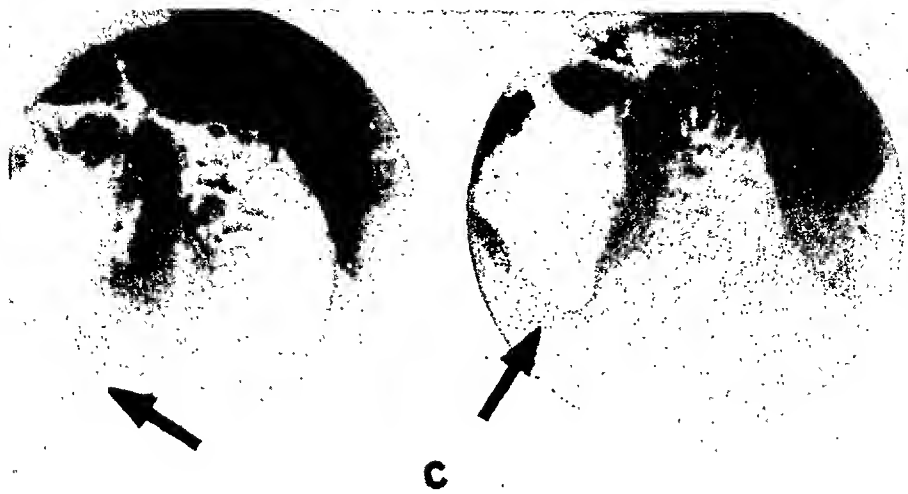

Fig. 3, C. Amebiasis of the Cecum with Improvement Following Oral Medication.

A man aged 36 (Unit No. 707511) was admitted April 22, 1943, because of recurrent diarrhea. He had lived in various parts of the world. Two years before admission, while living in a Latin American country, he had diarrhea for a month, which was thought to be bacillary dysentery. He was well for six months and then had a tapeworm. Five months before admission the diarrhea recurred and continued intermittently. When blood appeared in the stools he was given sulfaguanidine and the diarrhea stopped. Ten days before admission it began again, lasting five days, with "gas pains" and weakness. The patient lost 20 lb. in weight. On admission he felt well, and had no diarrhea, but stools contained mucus and flecks of blood. Sigmoidoscopy disclosed several depressed areas in the mucosa, which suggested healed ulcers. Exudate taken from around these depressions failed to disclose amebae and the physician thought amebiasis was excluded. A barium enema, April 21, 1943, disclosed hypertonicity and irritability of the sigmoid, and a deformity of the cecal tip. Fig. 3, *A*, is the post-evacuation film. Because no mass could be felt, this cecal deformity was interpreted as highly suggestive of amebiasis.

A few days later the patient was readmitted for further studies with barium by mouth. The morning of admission he passed a loose stool in which active amebae containing red cells were demonstrated. Barium was given by mouth, April 27, 1943. Fig. 3, *B*, shows two pressure films of the shortened, ragged-appearing cecum with a normal terminal ileum, taken at about four hours. The patient was given two courses of anayodin and returned to his business in a Latin American country. He was readmitted June 16, 1943, because of fever up to 104° with generalized aches and pains, which were at first attributed to grippe. The white cell count was 18,000 with 75 per cent neutrophils. The stools contained *E. histolytica*. Anayodin was started again and the patient was discharged June 26, with the temperature still elevated.

Another small intestine study was done July 26. Fig. 3, *C*, shows pressure films of the cecum taken at about four hours. The terminal ileum appears normal. The cecum is larger and smoother than in *B* but shows two marginal defects suggesting small elevations on the mucosa. Just below the ileocecal junction is a marked constriction. Although the cecum was improved in appearance, it was still abnormal.

The patient was readmitted July 27, with a fever of 100–101°. Emetine therapy was started, and six days later the temperature was normal. There was no clinical evidence of a liver abscess. Unfortunately no further x-ray studies were possible. The conduct of this case was definitely influenced by the x-ray demonstration of the deformity of the cecum.

other had a rectal stricture; all 3 had proved amebiasis.

No cecal deformity was demonstrated in 33 (57 per cent) of the 58 patients with positive stools who had examinations with barium. This shows clearly that failure to demonstrate an abnormality of the cecum or elsewhere in the colon is of no importance in excluding amebiasis.

Deformities distal to the cecum were present in the remaining 4 (7 per cent) of the 58 patients with positive stools.

Although we have no statistics to prove it, our experience indicates that cecal studies made following the ingestion of barium are more satisfactory and accurate than those made with the barium enema. The patient is not uncomfortable. Repeated observations with pressure films can be made. The terminal ileum can be studied at leisure. Care must be taken not to mistake incomplete filling for deformity of the cecum. However, the barium enema is necessary for the examination of the distal colon, the second commonest site for amebic lesions. The best procedure is to use both.

The cecal deformity varied considerably. In some cases it was slight and amounted to narrowing of the tip, an appearance well

Fig. 4. Amebiasis with Deformity of the Cecum which did not Change Following Diodoquin but which *Improved* after Emetine.

For history, see opposite page.

illustrated in Bell's articles; in a few the cecum was so shrunken that its shadow measured only 2 or 3 cm. in diameter (Fig. 1). In the great majority the outline was smooth. Much less frequently the cecum was irregular in outline (Fig. 3) and narrow without much shortening (Fig. 4). The size and outline of the cecum often changed a little from time to time; this was particularly noticeable when the deformity was relatively slight. In some instances pressure on the cecum appeared to cause an increase in the deformity. Localized tenderness was usually elicited.

In none of the cases was the terminal ileum narrowed or intrinsically deformed. In very few it appeared to be immovable and was coiled in an abnormal position (Figs. 1 and 5). Lesions in the terminal ileum were not found in the 3 cases examined by the pathologists. In one case, although the lumen was not narrowed, the smoothness of the shadow and obliteration of the folds suggested edema of the mucosa (Fig. 1); this appearance disappeared after treatment. In a few cases the terminal ileum obscured the cecum. Spot films with and without pressure, with the patient rotated one way or the other, were sometimes necessary to separate the ileal from the cecal shadow. No case proved to have amebic lesions in the ileum has been reported in which barium studies were done, as far as we know. Therefore, we do not know what, if any, abnormality demonstrable by x-ray methods might be expected in the ileum in such a case.

EFFECT OF TREATMENT

As pointed out by Bell, the small deformed cecum may relax and increase in size with anti-amebic treatment. Re-examination was done after treatment in only 5 of our cases. In 4 of them, relaxation of the cecum, suggesting improvement, was demonstrated. Figure 3 illustrates improvement following oral therapy, but the cecum did not become normal and, although diarrhea stopped, fever continued until a series of injections of emetine was given. Unfortunately another re-examination was not done. In Figure 4 little change in the cecum occurred following oral therapy, but marked improvement resulted from a combination of emetine and diodoquin. In another case (Fig. 1) with extreme shrinking of the cecum, little change in its size or shape could be demonstrated following the specific treatment, which produced complete relief of symptoms. It would seem that in later stages the changes produced by the disease are irreversible.

CAUSE OF THE CECAL DEFORMITY

Abnormality of the cecum demonstrable by roentgen methods is not present in nearly two-thirds of the cases of amebiasis, although the great majority of them undoubtedly have lesions in the cecum. However, in over one-third of the cases, cecal deformity is present. The reason it appears in one case and not in another is not clear. Inasmuch as cecal deformity is present more than five times as frequently in patients with diarrhea or other intestinal symptoms as in those with neither, it seems probable that the severity of the infection and, therefore, the number of lesions may play a part. No observations are available to indicate how soon after infection cecal deformity may appear. The fact that the small cecum relaxes under treatment indicates that the deformity is due in part at

Fig. 4. Case History.

A 35-year-old man (Unit No. 639076) was admitted Nov. 15, 1943, because of pain in the right lower quadrant and watery diarrhea. A barium enema, Nov. 15, and a small intestine study, Nov. 18, disclosed narrowing and deformity of the cecum. Fig. 4, *A*, is the six-hour film. The terminal ileum was not abnormal. Amebiasis was suggested in the report. Three stool examinations were negative and the fourth was positive. Diodoquin was given from Nov. 30 to Dec. 10. A stool on Dec. 17 was negative.

Pain and tenderness in the right lower quadrant recurred and the patient was readmitted Jan. 4, 1944. A barium enema Jan. 5, 1944 (*B*), showed the cecum to be a little longer but no wider than it was on Nov. 18, 1943. A course of emetine was given, followed by a course of diodoquin, with relief of symptoms. A barium enema Feb. 15, 1944, showed relaxation of the cecum. *C* is the postevacuation film following a barium enema April 17, 1944. The cecum was much larger and regular in outline.

Fig. 5. Amebiasis of the Cecum with No Diarrhea.
For history, see opposite page.

For history, see opposite page.

least to spasm. The amebic lesions in early stages are confined to the mucous membrane. In the small intestine it has been shown that mechanical stimulation of the mucosa causes relaxation of the muscularis. Stimulation of the mucosa alone by the lesions would probably not tend to cause spasm. The information available concerning the pathology of this disease indicates that early lesions confined to the mucosa are not associated with secondary infection. On the other hand, Faust stated that in chronic amebiasis secondary bacterial infection is usually present. It seems possible, therefore, that after the ulcers penetrate into the submucosa and a secondary infection occurs, then spastic contraction of the cecum may be caused by direct irritation of the muscularis. On the other hand, it seems improbable that cecal deformity would be caused by uncomplicated superficial mucosal ulcers alone. In 2 of our cases the coiling and immobility of the terminal ileum suggested that the inflammatory process had extended into the peritoneum. However, much more work needs to be done in detailed studies of the pathology in cases with deformed cecums before the mechanism of the deformity can be understood.

DIFFERENTIAL DIAGNOSIS

Deformity of the cecum may be produced by carcinoma, by tuberculosis, and by regional enteritis.

Tuberculosis involves both the cecum and the ileum in the vast majority of cases, is confined to the ileum alone infrequently, and to the cecum alone in less than 5 per cent of the cases. The demonstration of a normal terminal ileum is strong evidence against tuberculosis. However, as Bell pointed out, hyperplastic tuberculosis of the cecum could simulate the cecal deformity described above. We have seen hyperplastic tuberculosis of the cecum in only 2 cases, and the ileum was involved in both.

Likewise, regional enteritis involves the cecum infrequently and the ileum commonly. We have not seen a case of regional enteritis confined to the cecum. In both tuberculosis and regional enteritis the terminal ileum is narrowed or irregular in outline.

Carcinoma of the cecum usually produces an irregular asymmetrical filling defect associated with a palpable mass, whereas the deformity of amebiasis is symmetrical and in the majority of cases is smooth and regular and is not associated with a palpable mass. In most of them the deformity may change a little from time to time, whereas the defect of carcinoma is usually unchanging. A mass produced by a large amebic granuloma of the cecum could not be differentiated from carcinoma.

Amebiasis of the cecum appears to be more frequently encountered in the patients seen at the Presbyterian Hospital than carcinoma or tuberculosis of the cecum. In the ten years preceding Dec. 31, 1943, the record room files show 67 cases of carcinoma of the cecum and only 12 of ileocecal tuberculosis.

Errors in interpretation in our series were few, as amebiasis was mentioned in the report of the roentgen examination in 22 of 30 cases with cecal deformity. In 2 cases the deformity of the cecum was interpreted as carcinoma (Fig. 2) and tuber-

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Fig. 5. Case History.

The 40-year-old wife of a doctor in one of the West Indies islands came to New York for medical care because of intermittent right lower quadrant pain of seven years' duration, which was increasing in severity. There was no history of diarrhea. Fig. 5, *A*, shows the right lower quadrant about four hours after the ingestion of barium. The terminal ileum and the ileocecal junction can be identified without difficulty. Ileal loops are superimposed in the cecal region in such a way that the cecum cannot be identified. By rotating the patient to the left the cecum could be seen.

Fig. 5, *B*, shows two spot films without pressure. The cecum (1) is peculiarly deformed. A loop of lower ileum is superimposed upon it. The cecum and adjacent ileal loops were immovable (ileocecal junction, 2; terminal ileum, 3). Because of the deformed cecum, a search for amebae was suggested and the organisms were quickly found. Treatment was followed by symptomatic relief.

The demonstration of the cecal deformity saved this patient an exploratory operation. Undoubtedly pericecal adhesions are present, which involve adjacent ileal loops. This made the identification of the deformed cecum difficult. The case illustrates the importance of careful fluoroscopy with spot films.

Fig. 6. Stricture of the Rectum, Deformity of the Cecum, and Relaxation of the Ileocecal Valve with No Positive Proof of Amebiasis.

For history, see opposite page.

culosis, respectively. The one error was unfortunate, as it led to an unnecessary operation. Both errors were apparently made because the observers did not think of the possibility of amebiasis. In 2 reports, abnormality of the cecum was mentioned but was not interpreted, probably because the observers did not know what to say but were convinced the disease was neither malignant nor tuberculous. In 4 instances the observer apparently did not see the deformity. In only 2 instances in our series was deformity of the cecum associated with other lesions in the large intestine; in one case the rectum (Fig. 6) and in the other the ascending and transverse colon was involved. Flexible narrowing or irregularity of the wall distal to the cecum can be taken as additional evidence that the cecal deformity suggests amebiasis. Clark's necropsy statistics suggest that with the heavy infections which occur in some geographic regions multiple areas of involvement might not be as infrequent as in our series of cases.

Probably the greatest difficulty lies in the recognition of the milder stages of the deformity. How great is the danger of mistaking functional changes in the shape of the cecal tip for the spasm induced by amebiasis? Contraction of the cecum under the stimulus of pressure is not at all infrequent. This reaction is usually present in the well advanced deformities unquestionably associated with amebiasis. Can irritation from the appendix produce a spasm of the cecal tip? Suppose the cecum appears normally filled out and rounded at the six-hour period and at twenty-four hours appears small and pointed, can this be taken as evidence of disease? These and similar questions are puzzling at the present time; many careful correlations with clinically proved cases will be necessary before they can be answered.

We have the impression that a deformity which is not persistent is probably not significant. If a cecum contracts under the stimulus of pressure and promptly relaxes, the movement is probably normal. On the other hand, if the cecum contracts under pressure and stays contracted, particularly if it seemed a little small before it contracted, and if localized tenderness is present over the cecal tip, it seems reasonable to raise the question of amebiasis. This should be presented to the clinician as a suggestion, not as a diagnosis, and should be so accepted by him.

The difficulty of demonstrating the organisms in the stools of some patients, particularly those with obscure atypical symptoms due to amebiasis, is well recognized. Schulze and Ruffin (1942) called attention to the fact that other disease may coexist with amebiasis. These writers believe that a trial of specific therapy is justified to prove the diagnosis in suggestive cases in which the organism cannot be demonstrated.

It is of interest that in standard textbooks (*e.g.*, Craig and Faust), and in authoritative articles (*e.g.*, Faust, 1944) no mention is made of barium procedures as a method of demonstrating amebic lesions in the large intestine. Schulze and Ruffin (1942) stated: "Barium studies of the colon are sometimes suggestive but rarely, if ever, justify diagnosis." They did not describe what abnormalities of the barium shadows of the colon they would accept as suggestive of amebiasis. In this sense a filling defect in the stomach does not justify a diagnosis of carcinoma because other diseases such as syphilis or lymphosar-

Fig. 6. Case History.

A 42-year-old woman (Unit No. 522696) was admitted because of alternating constipation and diarrhea, and rectal bleeding. A barium enema (Fig. 6, *A*) disclosed narrowing and irregularity of the rectum. Barium by mouth disclosed shrinking and deformity of the cecal tip with a normal terminal ileum (*B*). The ileocecal valve was widened and relaxed.

This is one of the relatively few cases in this series which showed the abnormality of the ileocecal valve described by Weber. Amebiasis was suggested. One stool examination was negative for amebae. Biopsies from the rectum showed evidence of inflammation, but no amebae could be identified in the tissue. The Frei test was negative. The surgeon is not inclined to accept amebiasis as the probable explanation for this disease, and nothing further has been done to prove the diagnosis.

coma may also produce it. Furthermore, carcinoma may be present with no demonstrable deformity of the stomach. Yet the clinical value of the roentgen examination of the stomach cannot be denied. Because the barium method of examination of the digestive tract is so universally used, it is quite likely to be applied in cases with obscure abdominal symptoms such as those described by D'Antoni and others in amebiasis. If the significance of cecal deformity without narrowing or irregularity of the terminal ileum is recognized, a number of cases of amebiasis will be found which otherwise would escape detection. At the same time it must be emphasized that the procedure has no value whatsoever in ruling out this disease.

SUMMARY

A group of 119 cases of proved or suspected amebiasis was studied. Of these, 67 had x-ray examination with barium, which disclosed deformity of the cecum in 30. Twenty-one of the 30 had proved amebiasis. In the other 9 cases the disease was not disproved. Of 58 patients with amebae in their stools, 33 had no abnormality of the cecum demonstrable by x-ray methods. Experience with this series suggests that recognizable deformity of the cecum is likely to be present in over one-third of the cases of amebiasis. Cecal deformity is much more likely to be found in patients with than in those without intestinal symptoms. Its absence is of no value in ruling out amebiasis, as deformity was not found in almost two-thirds of the patients with this disease.

Recognition of the cecal deformity has proved clinically valuable in a number of cases in which the first suggestion that amebiasis might be present came from the x-ray examination.

Inasmuch as amebiasis is not uncommon in temperate climates and as it will probably be found more frequently with the return of our military forces from all parts of the world, it seems evident that the significance of cecal deformity deserves attention.

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Roentgen Findings in Amebic Disease of the Liver[1]

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Amebic disease of the liver is the most common complication of amebic dysentery. It is far more common among visitors to the tropics than among the native population. The ratio is often put at 10 or 20 to 1. Of 222 cases of amebic dysentery reviewed, 32, or 14 per cent, showed liver involvement.

The purpose of this paper is to emphasize—or perhaps to re-emphasize—certain pertinent facts about the diagnosis of amebic liver disease, in the light of experience in an Army Hospital. The writer makes no claim to originality for his observations. Because of the obvious difficulties in an overseas theatre, the literature on the subject has not been reviewed.

Two stages of the disease have been seen at this hospital. The first stage is a diffuse hepatitis, similar to hepatitis of other origin, except that very few cases of amebic etiology show clinical jaundice. This is the earliest stage of the disease; no pathognomonic signs exist and the diagnosis is dependent upon a carefully taken history, suggestive physical signs, and sometimes a therapeutic test.

The stage of hepatitis may or may not progress to the second stage, that of a full-blown abscess or multiple abscesses. It is often difficult, or even impossible, clinically to differentiate between the two stages. If early specific treatment is instituted, it may never become definitely established whether or not actual abscess formation has been present. For this reason, and because aspiration of an abscess was indicated in only a very small percentage of cases, it has been the custom at this hospital to make no distinction between the two stages for purposes of classification. Unless aspiration became necessary and pus was actually obtained, all cases of amebic disease were designated as amebic hepatitis.

CLINICAL COURSE

The *Endamoeba histolytica* reaches the liver through the portal circulation from ulcerations in the mucosa of the colon. Obviously, then, amebic dysentery must always precede hepatitis, although sometimes no such history can be elicited.

The onset is usually insidious. The patient may not appear very ill. He complains of anorexia, malaise, and vague discomfort in the epigastrium, radiating to the right hypochondrium and sometimes to the right shoulder. There is almost always a history of previous short attacks of diarrhea, sometimes going back four to six months. A low-grade fever and moderate leukocytosis are invariably present and the sedimentation rate is elevated. The liver may or may not be palpable, but there is invariably tenderness over the hepatic area. Pain can often be elicited on anteroposterior compression of the right lower chest.

At times, the onset may appear to be very sudden and the clinical course of the disease stormy. The patient may appear gravely ill with a high spiking fever and a large, palpable, tender liver.

ROENTGEN FINDINGS

On x-ray examination, two groups of cases will be found. In one group, comprising approximately 50 per cent of the cases, either there are no x-ray signs whatever, or there may be a downward enlargement of the liver, as shown on a survey film of the abdomen by displacement of the liver edge to a variable distance below the costal margin. The film should be made with the patient in the prone position, at the end of expiration. These cases are undoubtedly those of diffuse amebic hepatitis, similar to hepatitis of other etiology except that they respond dramatically to emetine.

In the second group of cases

[1] Accepted for publication in May 1945.

frank liver abscesses with positive x-ray signs on the chest film. Of the 32 cases here reviewed, only 22 were examined roentgenologically. Of these, 10, or 45 per cent, showed positive evidence of liver disease on the chest film. The right dome of the diaphragm is elevated, usually for at least one interspace. Only the outer portion of the leaf may be raised, so that the costophrenic sinus is flattened out, but the cardiophrenic angle may be intact. Or only the mesial portion may be high, so that the cardiophrenic angle is obliterated. At times, elevation is limited to the midportion of the leaf, as though the upward convexity of the dome were markedly accentuated. In this latter instance both the costophrenic and cardiophrenic angles are sharpened.

When present, elevation of the right diaphragm is the most unequivocal sign of amebic liver abscess. It not only clinches the diagnosis, but it is most valuable in checking on the therapeutic results. It will be found that, while clinical response to specific treatment may be dramatic, the x-ray signs will be much slower in returning to normal.

On a lateral view of the chest, besides the elevation of the right diaphragm, a more localized bulge may sometimes be made out, usually in the anterior half of the dome, directed upward and forward.

If the patient is examined fluoroscopically, it will be found that the right diaphragm either shows no excursions at all or its movements are very sluggish, the right dome descending only slightly as compared with the left.

The right lower lung field sometimes shows secondary changes. The bronchovascular markings in the right base may be crowded, and at times the picture resembles that of a primary atypical pneumonia, except for the abnormality of the diaphragm. The condensation of the lung markings is probably due to compression by the high diaphragm. The infiltration, on the other hand, is probably to be attributed to interstitial pneumonitis or perhaps to partial atelectasis. In a certain percentage of cases a frank pleural reaction is seen in the right costophrenic angle; a narrow band of thickened pleura is seen running up toward the axilla and there may be a small amount of fluid in the costophrenic sulcus. These are probably cases of liver abscess which have ruptured into the pleural cavity. Often, under these circumstances, the underlying amebic disease is not suspected clinically. All the symptoms and physical signs are referable to the chest, and the diagnosis may first be made on the x-ray evidence.

From a roentgenologic point of view, then, it may be said that in regions where amebic dysentery is prevalent, abnormal elevation of the right diaphragm should always make one suspect amebic disease of the liver.

CASE REPORTS

CASE I: Ch. L., white, 38 years old, was admitted to the hospital June 10, 1943, with a history of anorexia and pain in the umbilical region of four days' duration. Pain was constant and radiated to the right upper quadrant. There was no vomiting or diarrhea. The liver was palpable two fingers breadth below the costal margin and very tender. The temperature varied between 99 and 102° F., and there was a moderate leukocytosis. Stools were negative for *E. histolytica* on ten successive examinations.

X-ray examination on June 15 revealed a slight elevation of the right dome of the diaphragm (Fig. 1, A). Costophrenic sinuses and lung fields were clear. Re-examination on June 22 showed the right diaphragm to be in a slightly higher position (Fig. 1, B). There were increased lung markings throughout the lower half of the right lung field, probably due to compression. Fluoroscopic examination of the chest on the same day showed the right diaphragm moderately elevated and almost completely immobilized. Only its mesial portion showed very slight movement. A survey film of the abdomen of the same date showed the liver edge displaced downward, 5 cm. below the costal margin (Fig. 1, C).

A diagnosis of amebic liver abscess was made and specific treatment instituted. The patient responded well to emetine therapy (Fig. 1, D) and was discharged to duty on July 22, "improved."

CASE II: J. J., colored, 36 years old, was admitted on Aug. 18, 1943, with a chancroid lesion of the penis and regional lymphadenitis. During his stay in the hospital he began to run a high spiking temperature, fluctuating between 99.5 and 101° F., with daily remissions. X-ray examination of the chest on Aug. 25 and 26 revealed elevation of the

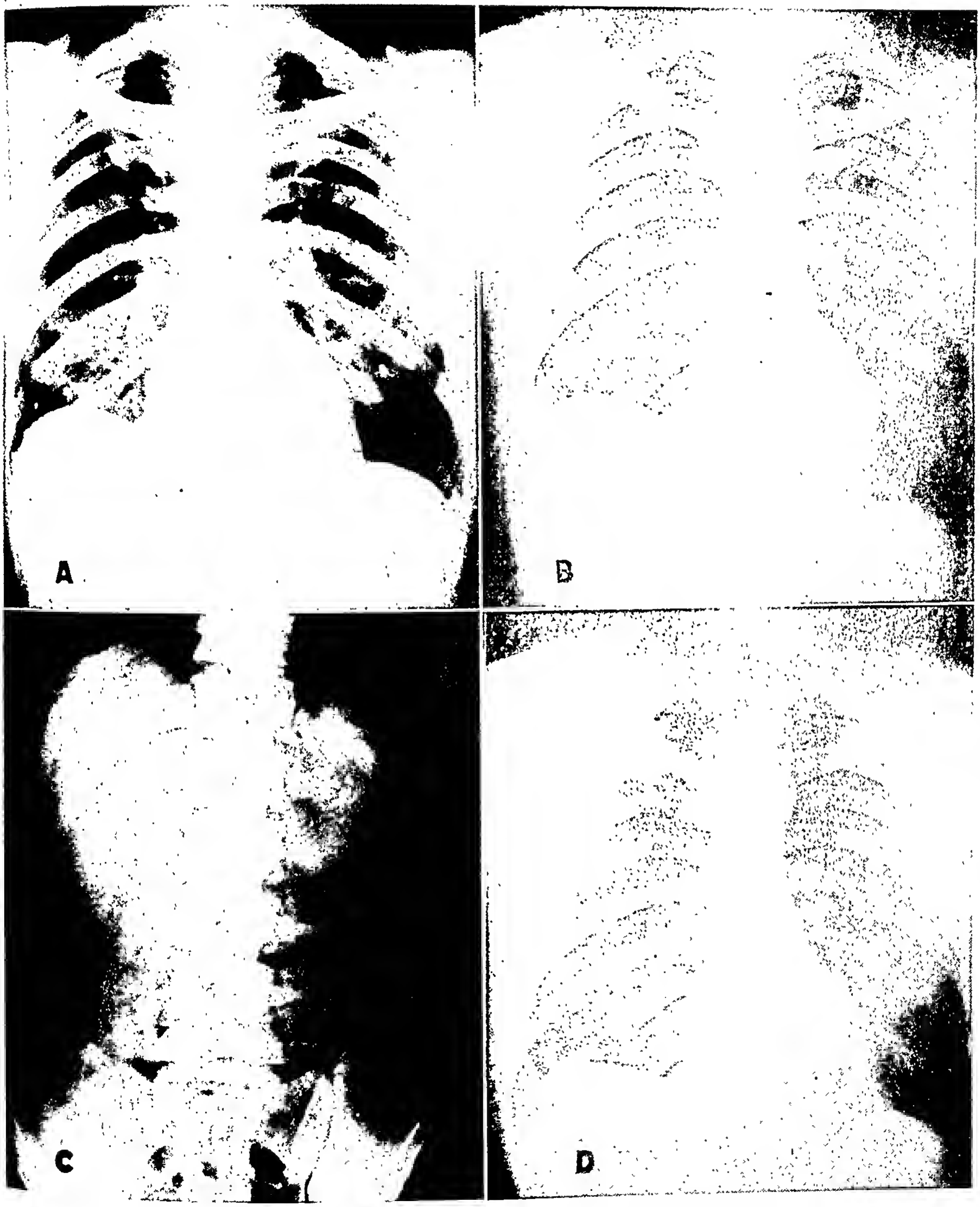
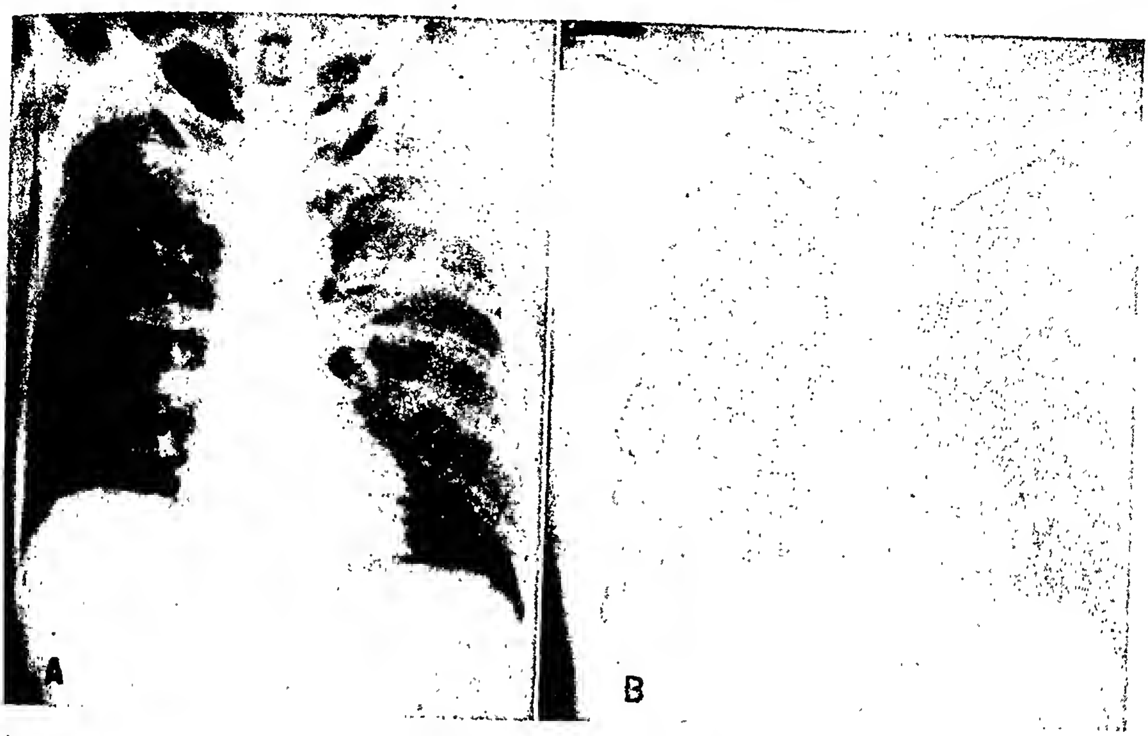


Fig. 1. Case I. A. Right diaphragm in high position; lung markings in right base crowded. B. One week later: right diaphragm higher; costophrenic sinus obliterated. C. Same day as B: Liver edge about 5 cm. below costal margin. D. Right dome lower, following emetine therapy, though not yet entirely normal in position; costophrenic sinus clear.

Fig. 2. Case II. A. Moderate elevation of right diaphragm. B. Next day: Right diaphragm much higher; costophrenic sinus flattened out. C. Diaphragm lower following emetine therapy. D. Right diaphragm normal in position



ig. 3. Case III. A. Elevation of right diaphragm. B. One month later: right dome in normal position, one whole interspace lower than in A.

ight diaphragm, with blunting of the costophrenic nus (Fig. 2, A and B) and increased markings in the ght base, probably due to compression. The left iaphragm was also elevated by a distended colon. he diagnosis was amebic abscess of the liver. pecific treatment was started. The patient responded well to emetine (Fig. 2, C and D) and was ischarged to duty on Oct. 17. The venereal sions cleared on concurrent sulfathiazole therapy.

CASE III: Ch. G., white, 46 years old, was ad-itted on March 29, 1944, after a month in a base spital, where no definite diagnosis had been made. e complained of pain in the epigastrium and right per quadrant, nausea and vomiting, and fever, of er a month's duration. Diarrhea, present at the set of his illness, had ceased. The liver was palp-le two fingers breadth below the costal margin and tender on pressure. Pain was aggravated by deep breathing or lying on either side. Severe pain was elicited by anteroposterior compression of the right lower chest. There was a leukocytosis, and the sedimentation rate was increased (26 mm. in one hour). Stool examination was positive for *E. histolytica.*

Films of the chest and right abdomen taken on March 30, showed a slight elevation of the right diaphragm, especially in its mesial half (Fig. 3, A). The costophrenic sinuses and lung fields were clear. The liver edge was seen about 4 cm. below the costal margin. Three courses of emetine were given with gradual subjective improvement, decrease of the sedimentation rate, and return of the liver to normal size, though it remained tender. X-ray examination on April 30 showed the right diaphragm normal in outline and position (Fig. 3, B). The liver edge at the end of expiration was about 1 cm. below the costal margin. The patient was discharged to duty June 16, 1944, "improved."

CASE IV: C. G., 36 years old, was admitted to the hospital Sept. 12, 1944, with fever, anorexia, vomiting, and epigastric pain of five days' duration. He gave a history of diarrhea three months previously and, at the time of admission, was passing two watery stools each night. Examination was negative except for tenderness in the epigastrium and right upper quadrant. The liver was palpable two fingers breadth below the costal margin. The temperature varied between 103.5 and 99.5° F. The icteric index was 3.9. The sedimentation rate was elevated (65 mm. in one hour). The white blood cell count was 13,600, with 90 per cent polymorphonuclears. A malaria smear was negative. Stool examination was negative for *E. histolytica.*

X-ray examination, on Sept. 13, showed both sides of the diaphragm normal in outline and position (Fig. 4, A). The costophrenic sinuses and lung fields were clear. On Sept. 21 films of the chest and right abdomen showed a moderate elevation of the right diaphragm, especially in its mesial half (Fig. 4, B). The liver edge was displaced downward about 4 cm. below the costal margin. A diagnosis of amebic hepatitis was made and the patient was placed on emetine therapy. There was no response to a course of 6 daily injections of one grain. A

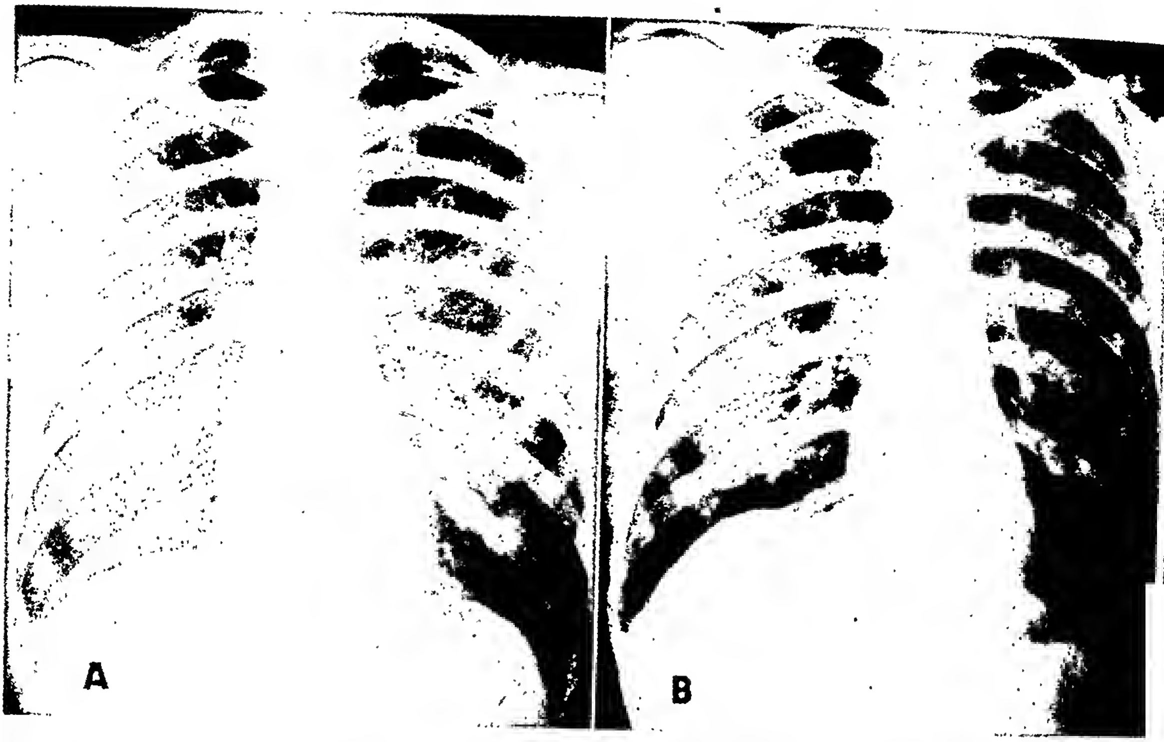


Fig. 4. Case IV. A. Right diaphragm approximately normal in position and outline (Sept. 13). B. Moderate elevation of right dome in mesial half (Sept. 21). See also Fig. 4, C.

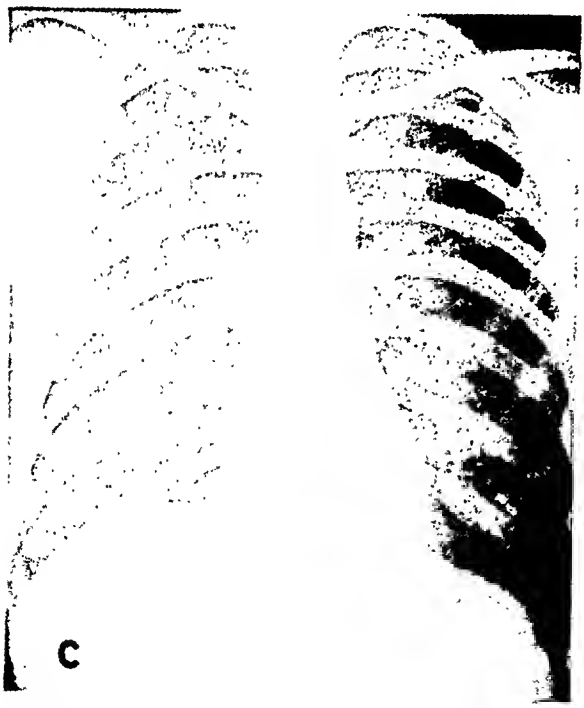


Fig. 4, C. Case IV. Oct. 9: Right diaphragm still elevated, but less than on earlier examination.

second course was given and gradual clinical improvement followed. Roentgen examination of the chest and abdomen on Oct. 9 showed the right diaphragm still somewhat high in position (Fig. 4, C), although to a lesser extent than previously. The liver edge was now seen 2 cm. below the costal margin. The patient was discharged to duty on Oct. 22, 1944, "improved."

CASE V: F. R. J., 44 years old, was admitted Sept. 13, 1944. The onset of illness was five days previous to admission, with severe pain in the right flank, general weakness, and profuse sweats. The right flank pain was intermittent, stabbing in character, and radiated through the right chest and to the right shoulder. The patient complained of frequency of urination and nocturia (three or four times a night). He had experienced no urinary symptoms prior to the onset of the illness. Physical examination showed marked pallor and deep tenderness in the right flank, but was otherwise negative. The temperature was 100.5° F. on admission and fluctuated between 104 and 100° F. for the next few days. The white blood cell count was 16,500 with 84 per cent polymorphonuclears. The sedimentation rate was elevated. Urinalysis showed 1 + albumin, 8 to 10 white blood cells, and 6 to 8 red cells per high-power field. The blood pressure was 122/70. The patient was thought to have a severe perinephritis without evidence of perinephritic abscess. An excretory pyelogram, made Sept. 20, showed rather poor concentration by both kidneys, but was otherwise negative.

X-ray examination of the chest on Sept. 22 showed the right diaphragm high in position (Fig. 5). There was considerable mottling in the right base and costophrenic sinus, apparently representing pneumonitis. The x-ray opinion was: amebic dis-

case of the liver with secondary pneumonitis in the right base. Emetine treatment was instituted and the response was dramatic. The temperature promptly subsided, pain and tenderness disappeared, and the sedimentation rate dropped to normal. The patient was discharged to duty on Oct. 14, 1944, "cured."

SUMMARY AND CONCLUSIONS

Amebic disease of the liver is the most common complication of amebic dysentery. Of a series of 222 patients with amebic dysentery, 32 (14 per cent) had amebic disease of the liver.

Two stages of the disease can be distinguished: amebic hepatitis and amebic liver abscess. Differentiation between the stages is not always possible clinically.

In cases of hepatitis survey films of the abdomen show either no positive x-ray signs or only a downward displacement of the liver edge to a variable distance below the costal margin.

In regions where amebic dysentery is prevalent, elevation of the right diaphragm, with complete immobilization or diminished excursions, is a pathognomonic sign of frank liver abscess.

Pneumonitis in the right base, associated with a high right diaphragm, is probably secondary to amebic liver abscess, if other causes for the elevation of the dome can be ruled out.

Pleural reaction with or without a small effusion in the right costophrenic sinus in the presence of a high diaphragm is secondary to liver abscess and may indicate rupture of the abscess into the pleural cavity.

Fig. 5. Case V. Right diaphragm flattened and in high position. The right hilar shadow is enlarged and there is streaked and mottled pneumonic infiltration extending into the right base.

Most cases of amebic liver disease, whether in the stage of diffuse hepatitis or full-blown abscess, respond readily to specific treatment. In only a very small percentage does an amebic liver abscess require aspiration.

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An Evaluation of Automatic Exposure Control Equipment in Photofluorography[1]

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HISTORY OF AUTOMATIC TIMER DEVELOPMENT

LATE IN THE SUMMER of 1940, investigations were undertaken at the University of Chicago to develop equipment whereby radiographic exposure might be more effectively controlled than was possible by the customarily used anatomic measurement technic. Because the problems associated with exposure control in radiography are fundamentally similar to those in photography, the first work (4, 5) was directed toward the development of a roentgen-ray exposure meter comparable in principle and operation to the instruments commonly employed in photographic practice. This early research clearly demonstrated that, with care in design, an instrument whose performance is entirely satisfactory from the standpoint of consistency of results is not difficult to produce. At the same time, it appeared equally evident that such a device is not likely to be widely accepted because of certain inherent characteristics which limit its usefulness. For example, when an exposure meter is used to calculate the exposure factors of a particular anatomical structure under examination, it is necessary, for each film made, to make two exposures, one for taking an exposure meter reading and one for exposing the film. In addition to this objection, an exposure meter in general lacks the flexibility necessary for ready application to a wide range of radiographic technics. For these reasons, efforts were made to modify the exposure meter design so that the resulting equipment might be used to control radiographic exposure automatically, thereby not only eliminating the need for more than one exposure per film but also doing away entirely with the measurements and calculations normally carried out by the technician when making an exposure.

The product of this work was the automatic photoelectric timing mechanism (6), or phototimer, an instrument which was given its first clinical trial in November 1941, when it was installed on the spot-film fluoroscope in the University's Division of Roentgenology. This instrument, with only a few minor modifications, is still in operation today, some four years later. In this period it has performed an average of over 50 exposures per day, or a total of well over 50,000 exposures. Those who have used the fluoroscope regularly report a significant improvement in the quality and uniformity of the films. Furthermore, it is stated that no thought need be given the roentgen machine once it is adjusted at the beginning of the day's operations. The radiologist is thereby permitted to devote his entire attention to the patient and his clinical problems.

The photoelectric timing mechanism is fundamentally a rather simple device, consisting of a fluorescent screen, a multiplier phototube, and a condenser-thyratron-relay system. Since the instrument is so simple, it may reasonably be asked why its development has not been completed until recently. The answer is not difficult. The first investigations in automatic timer design were undertaken by Franke (2) in 1930. Although some progress was made, no practical results were achieved because the instrument that was developed employed an ionization chamber as the radiation detector. With the extremely weak

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radiation intensities encountered in radiographic practice, the output current of the ionization chamber was so small that the performance of the timer frequently became erratic. Furthermore, the spectral sensitivity of the chamber was not the same as that of the films then available. This has since been shown (5) to be incompatible with satisfactory timer performance.

No change in the status of automatic timing in radiography occurred until the development in 1939, by Zworykin and Rajchman (9, 10) of the 9-stage multiplier phototube, a device which is extremely sensitive to minute light intensities. Normally this tube is relatively insensitive to roentgen radiation but when covered with a fluorescent screen its response becomes very great. Indeed, its sensitivity is such that, when activated by the radiation intensities characteristic of radiography, the current output is several thousand times greater than that of even large ionization chambers. Furthermore, by the proper choice of the fluorescent screen for use with the phototube, the spectral sensitivity of the tube may be made to coincide with films exposed with and without intensifying screens. Thus the multiplier phototube successfully overcomes the difficulties previously encountered in automatic timer design. The tube became commercially available in 1941, after which advances in automatic exposure control equipment occurred rapidly.

Early in 1942 it became evident that the automatic photoelectric timing mechanism had very real potentialities in the improvement and simplification of radiographic technic, and a contract for the further development of the device was soon established between the Office of Scientific Research and Development and the University of Chicago. The research that followed has progressed in three directions. The first concerned itself with the development of a simple exposure meter which might be used on existing general radiographic equipment. In view of what has been said regarding the general impracticability of exposure meters, one may justifiably question this activity. An exposure meter is, however, a valuable tool under certain circumstances, as in orthopedic and portable radiography, and accordingly its development was pursued. That this work was not ill-advised is amply demonstrated by the recent report of Bell and Heublein (1). Furthermore, the exposure meter has proved an extremely valuable laboratory instrument, by which our knowledge of radiographic physics is being rapidly increased (8).

The second phase of investigation was directed to the development of automatic timers applicable to general radiographic equipment. An initial report of this work has been published (3). An additional communication will be prepared shortly and, accordingly, further reference to this research is not given here.

The third problem undertaken was the development of an automatic timing mechanism for use on photofluorographic equipment. In many respects this problem was relatively simple. Under these circumstances the same fluorescent radiation which is used to expose the photofluorographic film may be used to activate the automatic timer, a condition insuring satisfactory timer performance through a wide range of radiographic conditions without the need of the compensating circuits required in photoelectric timing mechanisms used in general radiography (6).

The first automatic timer for photofluorography was completed in the spring of 1943 (7). A second unit was installed in August of the same year on a 35-mm. photofluorograph belonging to the U. S. Public Health Service in Washington, D. C. In the next six months, 19 other units were constructed for photofluorographs belonging to the Coast Guard and Public Health Service. Several timers were also assembled for the Army and Navy.

FIELD EXPERIENCE

In the twelve to eighteen months since the installation of these photo-

graphic phototimers, sufficient time has elapsed to permit a reasonably accurate evaluation of their merits and shortcomings. One of the Public Health Service's timers has performed well over 100,000 exposures. Many others are not far behind.

The several medical officers who have been working with phototimer-equipped photofluorographs report a considerable improvement in the quality and uniformity of automatically exposed roentgenograms over films exposed in the usual manner. This improvement not only facilitates film interpretation but also promotes more rapid reading and reduces fatigue. It is also found that, whereas the usual photofluorograph requires two operating technicians, one to measure and position the subjects and one to adjust the roentgen machine's controls, only one technician is required when exposures are performed automatically.

So far there has been no report of phototube failure in any of the several phototimers. In fact, it appears that phototube life may be considered unlimited. Multiplier phototubes seem extremely stable when operated under the conditions encountered in phototimer practice. No detectable change in sensitivity has been recorded either during a day's operations or from time to time through the period of a year and more.

Since the construction of these first phototimers, a few circuit modifications have been made in order to correct several minor difficulties arising after field trial. These may be more readily appreciated by reference to Figure 1, a block diagram of the original photofluorographic timer circuit. As shown there, the instrument includes a multiplier phototube, a phototimer condenser, a cold cathode thyratron, a pair of power thyratrons, a contactor, a safety timer, indicator circuits, two power supply circuits, and an exposure switch. When the exposure switch is closed, the power thyratrons are activated, thereby operating the roentgen contactor, which in turn energizes the roentgen machine. Thereupon the multiplier phototube is activated by the fluorescent light falling on its sensitive surface and the resulting phototube current is collected by the phototimer condenser. When the charge appearing across the plates of the condenser reaches a certain level, the cold cathode thyratron is energized, thereby deactivating the power thyratrons and sequentially causing the opening of the roentgen contactor and the termination of the roentgen exposure. By adjusting the sensitivity of the multiplier phototube, the termination of exposure can be made to coincide with the instant at which the photofluorographic film has received a quantity of radiation which will insure optimal quality.

In the course of photofluorographic operation there may occur instances when

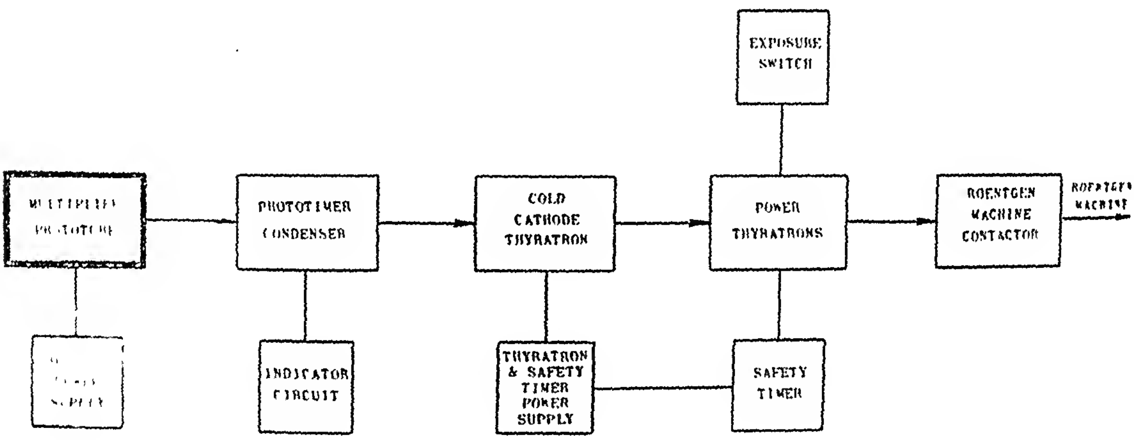

Fig. 1. Block diagram illustrating circuit arrangement of original automatic timer used in photofluorography.

a subject under examination will require a greater exposure than that tolerated by the roentgen tube if optimal radiographic quality is to be achieved. For this reason, the electronic safety timer is included in the circuit to prevent exposures beyond the safe limit of the roentgen tube. The inclusion of the electronic indicator circuit in the phototimer was prompted by the desire to have a mechanism to signal faulty operation of the device.

Soon after these phototimers were placed in operation, the circuit was simplified by the replacement of the power thyratrons by a small rapid-action relay. In addition, the electron indicator circuit was re-

In the original phototimer circuit, an exposure could be initiated by the exposure switch even though the power supply to the safety timer and thyratron circuit should fail. This situation was one to invite trouble, since, if power failure should occur, damage to the roentgen tube would almost inevitably be produced, because exposures would continue indefinitely until the exposure switch was released. This difficulty was corrected by placing the exposure switch directly in the thyratron power supply circuit so that an exposure could not be initiated in the absence of a properly functioning system.

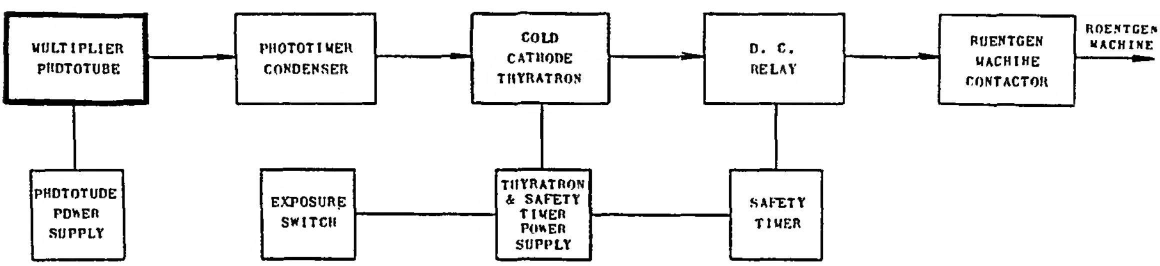

Fig. 2. Block diagram illustrating circuit arrangement of modified automatic timer now used in photofluorography.

moved because the infrequent occurrence of trouble made it seem superfluous.

Some of the phototimers after completing ten to fifteen thousand exposures developed an erratic performance which was traceable to irregular operation of the cold cathode thyratron. It was anticipated that trouble might arise in this part of the circuit because the power required to drive the thyratron was only slightly less than that delivered by the phototimer condenser. This difficulty might have been effectively overcome by the replacement of the cold cathode thyratron by a hot cathode type, a tube activated by extremely small amounts of power. The charge delivered by the phototube to the phototimer condenser is, however, of the wrong sign for operation of such a tube. The problem was solved by introducing a power amplifier tube between the phototimer condenser and the cold cathode thyratron.

A block diagram of the revised photofluorographic phototimer is shown in Figure 2. A schematic diagram showing the circuit in detail is presented in Figure 3. One such phototimer under test has performed over 250,000 exposures, with no evidence of failure. It therefore appears that this design may be expected to provide service equal to or in excess of that provided by the roentgen machine with which it operates.

COMMERCIAL PRODUCTION

During the time that these automatic timer developments have been in progress, several patents have been applied for under the recommendations of the Office of Scientific Research and Development. These patents, for the duration of the war, were assigned to the Government, which in turn granted free license to several manufacturers of roentgen-ray equipment to produce photo-timing ap-

paratus. Before long it is likely that the patent ownership will revert to the University of Chicago. In any case, free licensing will continue. This, taken in conjunction with the fact that little additional developmental work has been necessary on the part of the manufacturers, should make it possible to maintain thyratron has been omitted. It is difficult to predict the performance of these instruments, since more sensitive phototubes are now being used than was the case when this circuit gave trouble earlier in our experience. Results of field trials are awaited with interest.

It is anticipated that within the next

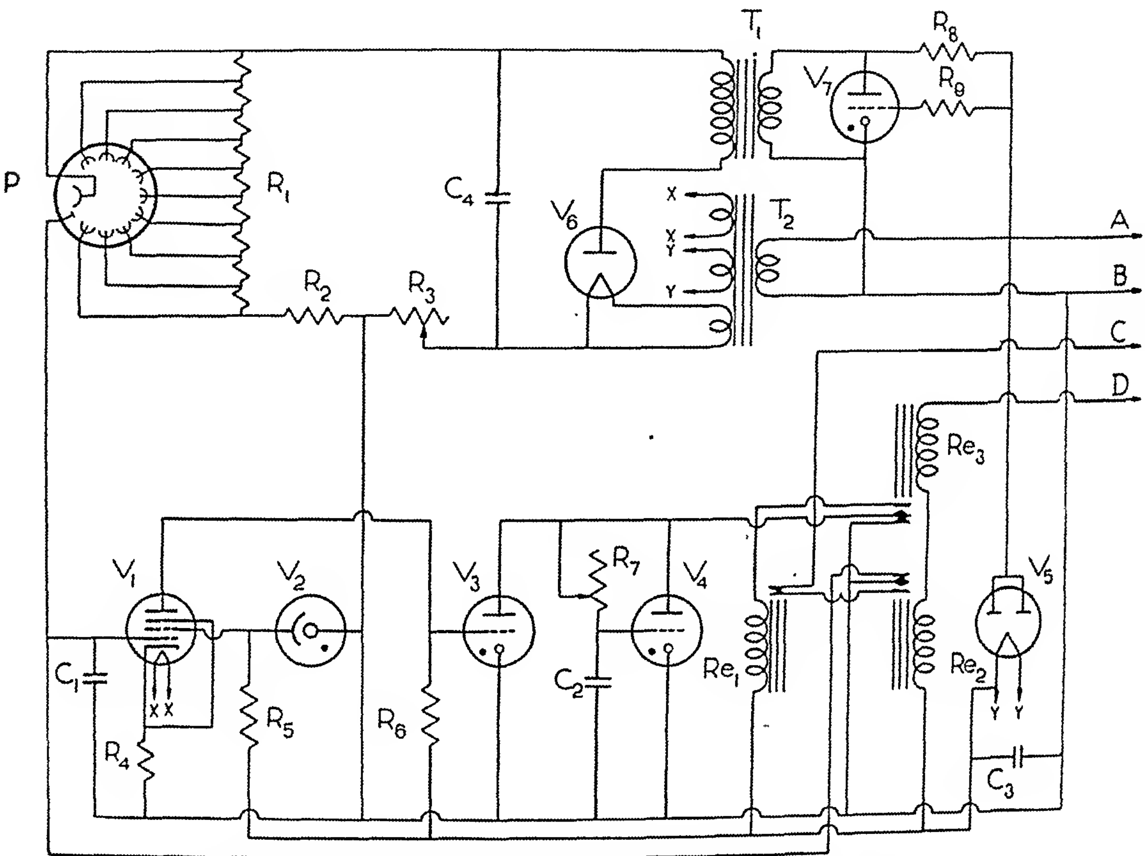

Fig 3. Schematic diagram illustrating in detail the modified automatic timer circuit. P, 931-A multiplier phototube. V_1, 6J7 amplifier tube. V_2, OC3/VR105 voltage regulator. V_3, V_4, and V_7, 1C21 thyratrons. V_5, 5Y3-GT rectifier tube. V_6, 2X2/879 rectifier tube. R_1, Nine 0.1-meg. resistors. R_2, 0.1-meg. resistor. R_3, 1.0-meg. potentiometer. R_4, 1,000-ohm resistor. R_5, 0.25-meg. resistor. R_6, 4,000-ohm resistor. R_7, 5.0-meg. potentiometer. R_8, 750-ohm, 25-watt resistor. R_9, 75,000-ohm resistor. C_1 and C_2, 0.25-mfd. condensers. C_3, 16-mfd. condenser. C_4, 1.0-mfd. condenser. T_1, High-voltage transformer. T_2, Filament transformer. Re_1, Re_2, and Re_3, single-pole, double-throw d. c. relays. A and B are connected to a 110-volt power source. The roentgen contactor's field coil is connected between A and C and the exposure switch between B and D.

the price of automatic timers at or near a level consistent with prices of conventional timers.

In recent months several manufacturers have begun commercial production of automatic phototimers for photofluorographic equipment. Three have followed the circuit design shown in Figure 3. Two others have done so with the exception that the power amplifier between the phototimer condenser and the cold cathode few years automatic timing equipment for general radiography will reach the same level of practicability as that now used in photofluorography. Very possibly, these developments will be sufficiently rapid to permit incorporation in post-war radiographic equipment when it first becomes available.

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An Unusual Case of Ewing's Sarcoma[1]

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THE FOLLOWING case of so-called Ewing's tumor is presented not because the disease is rare enough to warrant a single case report in the usual instance, but because this case did show some outstanding findings.

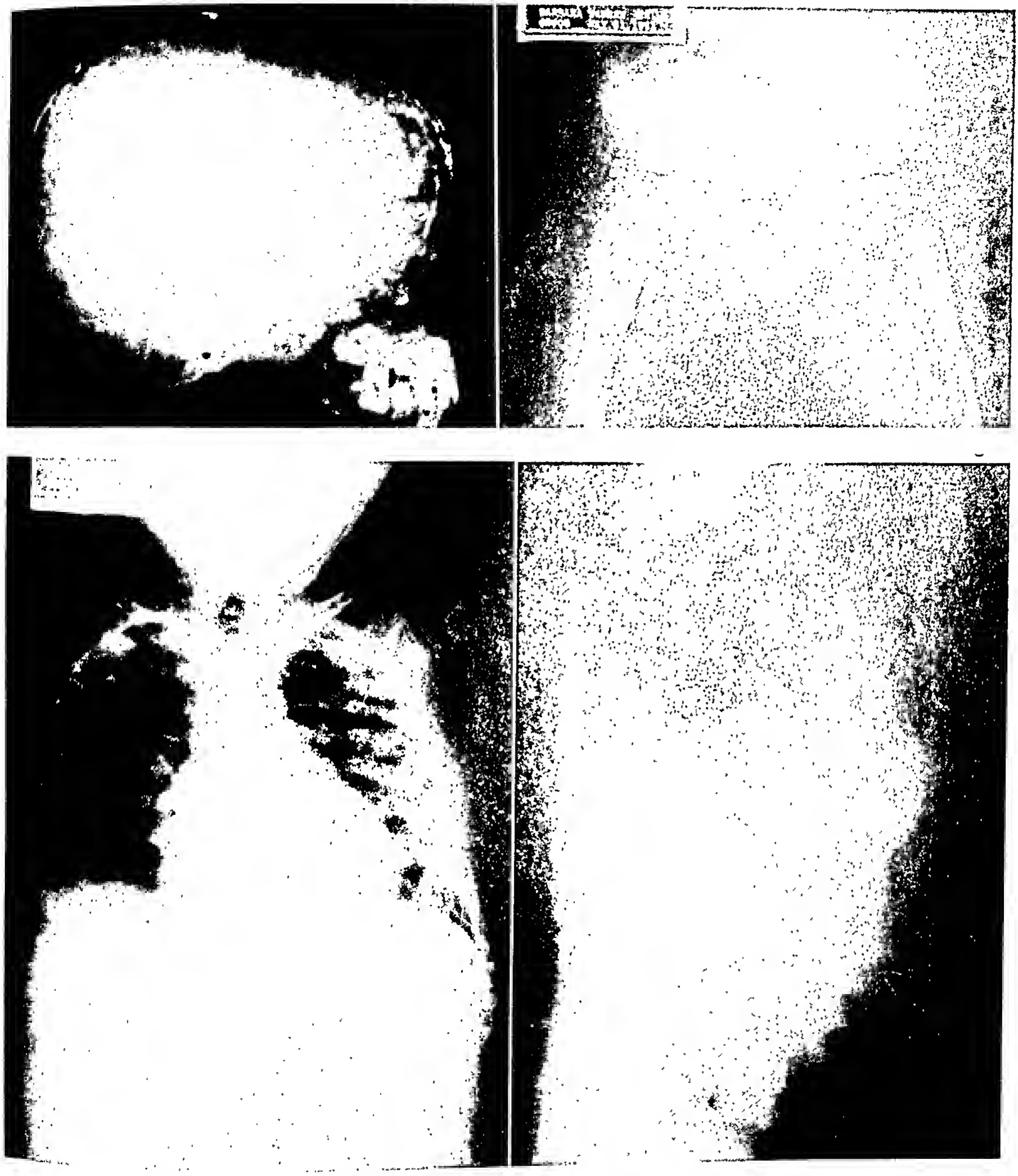
[illegible] Roentgenograms made in November 1940 (left) and March 1941 (right). The earlier film [illegible] lesions in the upper ends of both humeri. By March bone destruction had become generalized.

A [illegible] infant, aged 2 years, was admitted to [illegible] Hospital on May 31, 1941, with the following [illegible]

The [illegible] perfectly normal until October 1940. [illegible] noticed that she cried whenever the [illegible] upper extremity was moved, apparently because of pain in the shoulder. The pain grew progressively worse and the upper portion of the right arm became swollen. A febrile course followed, and a diagnosis of acute osteomyelitis was made on the basis of the clinical and x-ray findings (Fig 1). On Nov. 16, surgical drainage had been undertaken at another institution. Recovery was slow and never complete. There were two attacks of "bronchopneumonia" during December, and not until January 1941 was the wound healed. From December 1940 until the time of admission to Jefferson Hospital, the patient had repeated episodes of vomiting, which would persist for about a week, and she continued to lose weight and strength. Bouts of fever recurred at frequent intervals. A roentgenogram in January 1941 was reported as showing normal bones in the entire skeleton, except for the shoulder. In March, x-ray studies revealed generalized bone destruction (Fig. 2).

In May 1941, the child was admitted to another hospital. She was noted to be markedly undernourished, with a peculiar yellow color. Crepitant râles were heard in the lung fields. The liver was

[1] From the Department of Radiology, Jefferson Hospital, Philadelphia 7, Penna. Accepted for publication in January 19[illegible]



Figs. 3 and 4. Films made in May 1941, showing progressive skeletal involvement.

enlarged to two fingers below the costal cage. A soft movable mass was felt in the mid-abdomen, just below the umbilicus. There was a marked bilateral inguinal adenopathy.

Laboratory studies revealed a severe anemia, with hemoglobin 3 gm. The red cell count was 1,900,000; the white cell count was 31,000 with 76 per cent lymphocytes and 24 per cent polymorphonuclears. Some nucleated red cells were present. The Wassermann reaction was negative. The serum calcium was 12.5 mg. per cent, the serum phosphorus 3.8 mg. per cent, and the phosphatase 4.6 Bodansky units. The serum protein was elevated to 9.6 gm., per 100 c.c. with 4.0 gm. albumin, and 5.6 gm. globulin. No Bence-Jones protein was found in the blood or urine. X-ray studies of the skeleton showed extensive destruction of all the bones.

With three transfusions and daily liver extract parenterally, the hemoglobin rose to 7.0 gm. in eleven days, and the red cell count to 3,200,000. The white blood count dropped to 15,000. In spite of this, the patient continued steadily downhill, running a septic temperature, but apparently free from pain.

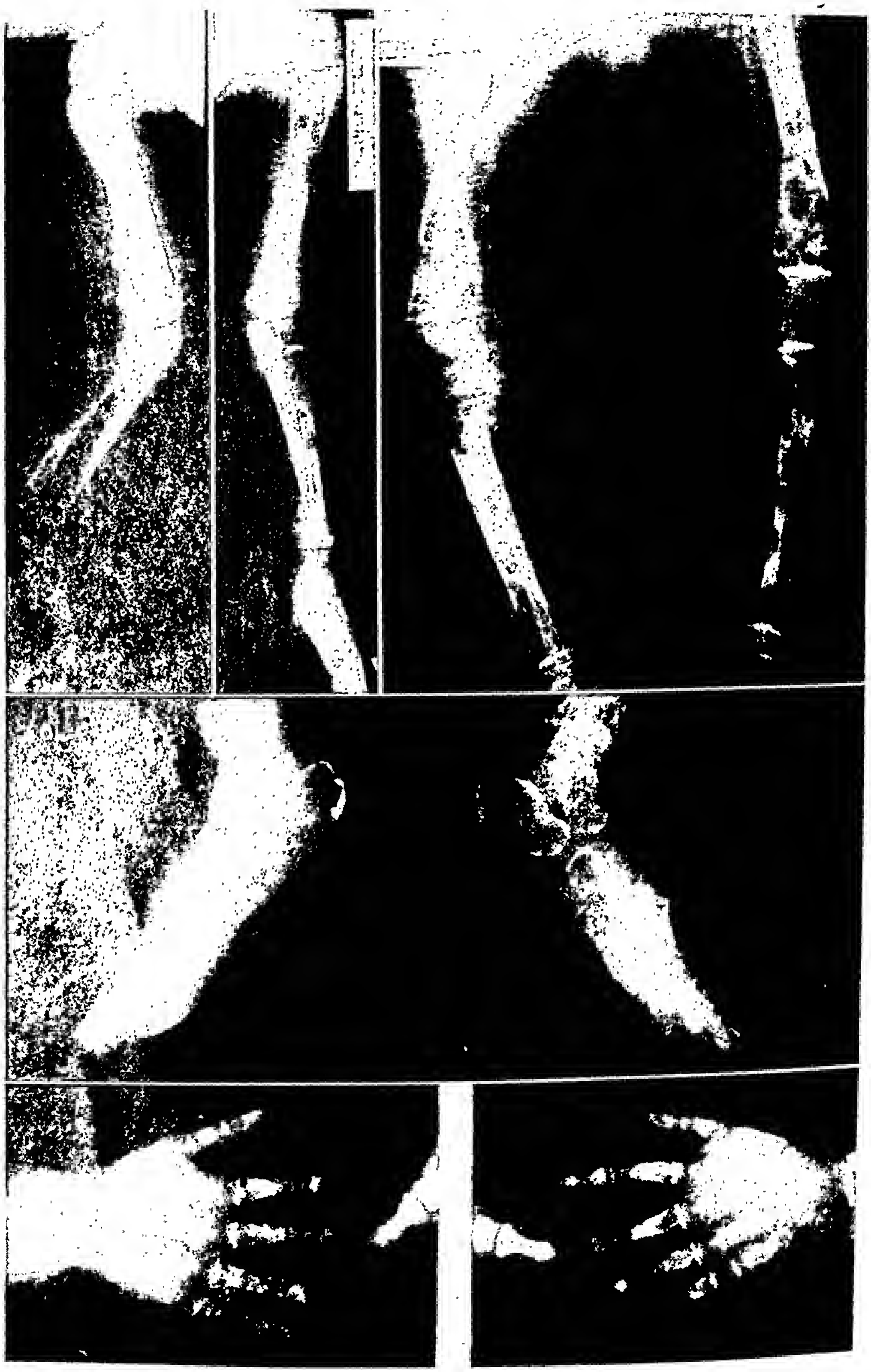


Fig. 5. Films made in May 1941, showing progressive skeletal involvement.

On May 31, 1941, the patient was transferred to the pediatric ward of Jefferson Hospital. The foregoing physical findings were confirmed. In addition, there was extensive nodulation in the scalp and over all the bony structures. Extensive cervical adenopathy was present. Peri-orbital edema had almost completely closed both eyes. Results of laboratory studies were approximately as previously reported, except that the serum phosphatase had now risen to 15.8 Bodansky units.

X-ray studies (Figs. 3–5) showed involvement of practically every bone in the body. There were no areas of bone production, but the entire skeleton was riddled with irregular areas of translucency of various sizes, resembling somewhat the cystic lesions of hyperparathyroidism, though that disease is rarely seen at this age. The cortices were expanded, thinned, and in many areas destroyed. There was no single area of healthy appearing bone in the skeleton. Even more remarkable was the extensive calcification of the arteries in both arms and thighs.

On June 12, under ether anesthesia, a biopsy specimen was removed from the left tibia (Fig. 6). The report by Dr. C. J. Bucher reads: "The section consists of tissue from a tumor of the bone. On section there is considerable necrosis of the bone. The tumor is very vascular and made up of a number of cells that have a scant cytoplasm and round, rather deep-staining nuclei. In most areas these cells are found about blood vessels and radiate out from the lumen of the vessel. In view of the history and histological character of the tissue, a diagnosis is made of Ewing's sarcoma."

The patient continued running a low-grade fever and died, apparently of respiratory failure, on June 12, 1941, twelve days after admission. Permission for autopsy could not be obtained.

Fig. 6. Photomicrograph of biopsy specimen showing a type of cell usually associated with so-called Ewing's tumor, with typical perivascular arrangement.

DISCUSSION

In spite of the absence of an autopsy, there can be little doubt that this was a case of Ewing's sarcoma, apparently arising in the right humerus, with metastases to the abdominal, cervical, and inguinal nodes, and to every bone in the body. The history, resembling osteomyelitis with rapid spread after bone curettement, is almost diagnostic, even without histologic confirmation.

The unusually rapid and extensive bone involvement is indeed remarkable. Within two months the skeleton was completely riddled. With such widespread involvement, the roentgen picture could have been mistaken for hyperparathyroidism. It is, moreover, very unusual for Ewing's tumor to be found in a patient of this age. The youngest patient in a recently reported series of 26 cases (1) was four years of age and there were only three in the first decade of life. Even more remarkable is the calcification of the arterial trunks of the upper and lower extremities. Not only is such calcification in infants unheard of, but we have definite x-ray evidence that this vessel calcification occurred in less than two months (cf. Fig. 2 and Fig. 3). We can speculate that the rapid and overwhelming bone destruction produced a hypercalcemia with subsequent metastatic calcification of the vessel walls. This seems plausible since on two occasions the serum calcium was over 12 mg. per cent (12.5 and 13.7).

The absence of demonstrable pulmonary metastases is also rather unusual, in view of the other extensive involvement.

One other point of interest is the completely osteolytic nature of the primary lesion in the humerus. This bears out the findings in another series studied by one of us (P.C.S.) that this is more common than

is the finding of various forms of bone production (1).

SUMMARY

1. An unusual case of Ewing's sarcoma in a two-year-old girl is described.

2. Within two months, metastases involved every bone in the skeleton, giving rise to a bizarre roentgen picture.

3. Extensive calcification in the arteries of the upper and lower extremities is an additional unusual feature of this case.

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Roentgenologic Visualization of the Fractured Temporal Styloid Process[1]

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FRACTURE OF THE temporal styloid process may occur in diffuse head and neck injuries or in the operative removal of the palatine tonsils. In the former event, it is but a single incident in a group of more important injuries. These may include fractures of the skull and of the cervical spine, atlanto-axial subluxation, sprain of the neck, loosening or tearing of the meniscus of the temporomandibular joint, and fractures or other injuries elsewhere. Fracture of the styloid process may be suspected when the patient has difficulty in swallowing or experiences pain between the mastoid process and mandibular condyle.

The styloid process of the temporal bone develops from two centers of ossification and may consequently be bipartite or multipartite. Its roentgenologic demonstration is often difficult, usually only the lower part being seen. It may be adequately shown in the open-mouth view of the edentulous patient (Fig. 1). Pancoast, Pendergrass, and Schaeffer, in their book on roentgen examination of the head and neck, stated that the bone is easily seen in posterior-anterior roentgenograms, especially those used for the examination of the maxillary sinuses. A lateral view of the nasopharynx and upper neck also shows it well. If the head is rotated a little, the two styloids are dissociated from each other.

We became interested in the roentgenologic visualization of the styloid process in connection with the following case, and a radiographic technic to show the full length of the bone was devised.

Fig. 1. The edentulous mouth allows fairly easy visualization of the styloid process in the routine open-mouth view.

CASE I: J. V., male, 30 years old, was struck on the left side of his head by the swinging doors of a speeding truck on March 19, 1940. The blow was a glancing one to the left frontal region, the skin being lacerated at that point. The patient was thrown to the ground so that he struck the right side of his head. He was unconscious for several hours and remained in a hospital for one day. Two neurologists who examined him because of constant dizziness and headaches agreed that he had sustained a cerebral concussion (with probable encephalopathy and right facial paresis). No roentgenographic signs of fracture of the skull were found. Some teeth and a denture were broken.

Severe pain occurred in the region of the right mastoid process when the jaw was shifted to the left, increasing in intensity when the same maneuver was done with the mouth open. Because of this, roentgenograms were taken of the jaw by the patient's dentist, Dr. H. H. Kaplan, Jr., and a fracture of the styloid process was revealed.

When the case first came to our attention April

[1] Accepted for publication in January 1945.

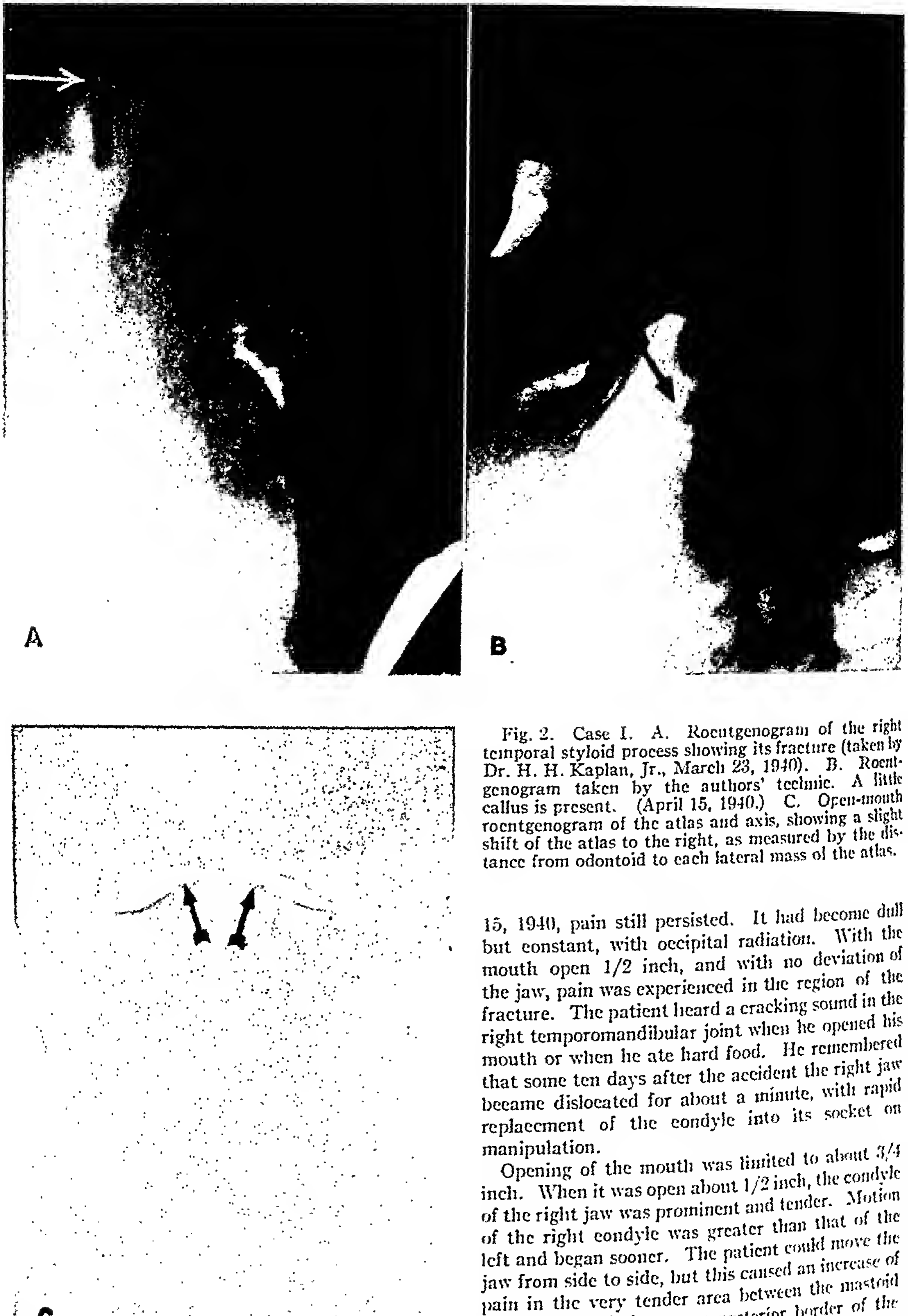


Fig. 2. Case I. A. Roentgenogram of the right temporal styloid process showing its fracture (taken by Dr. H. H. Kaplan, Jr., March 23, 1940). B. Roentgenogram taken by the authors' technic. A little callus is present. (April 15, 1940.) C. Open-mouth roentgenogram of the atlas and axis, showing a slight shift of the atlas to the right, as measured by the distance from odontoid to each lateral mass of the atlas.

15, 1940, pain still persisted. It had become dull but constant, with occipital radiation. With the mouth open 1/2 inch, and with no deviation of the jaw, pain was experienced in the region of the fracture. The patient heard a cracking sound in the right temporomandibular joint when he opened his mouth or when he ate hard food. He remembered that some ten days after the accident the right jaw became dislocated for about a minute, with rapid replacement of the condyle into its socket on manipulation.

Opening of the mouth was limited to about 3/4 inch. When it was open about 1/2 inch, the condyle of the right jaw was prominent and tender. Motion of the right condyle was greater than that of the left and began sooner. The patient could move the jaw from side to side, but this caused an increase of pain in the very tender area between the mastoid posteriorly and the upper posterior border of the vertical ramus of the mandible anteriorly. Motions

of the neck were good, but left lateral bending produced pain in the region of the fracture. (It should be noted that the patient had sustained a possible fracture of the middle fossa of the skull ten years before, but that he had been free of symptoms for at least six years before the recent accident.)

The roentgenogram made on March 23 by Dr. Kaplan (Fig. 2, A) showed the fracture of the right temporal styloid process about 1.5 cm. proximal to its tip. A roentgenogram (Fig. 2, B) made April 15 by a technic developed from that of Dr. Kaplan (described below) showed some healing of the fracture. The left temporal styloid process was normal. The cervical curve was much reduced, and an open-mouth view (Fig. 2, C) showed a shift of the atlas to the right with increase in the right intervertebral space between atlas and axis. In the open-mouth position the right mandibular condyle showed normal excursion to beneath the articular eminence, but the left condyle remained in its socket.

Fig. 3. Case II. The arrow indicates the site of fracture of the styloid process. This fracture was one of many injuries.

The principal obstacles to adequate roentgen visualization of the styloid process are overlapping of the bodies of the upper cervical vertebrae posteriorly and the mandible anteriorly. It is easy to demonstrate the distal end of the styloid, but it was necessary in the case reported above to show the entire bone. For visualization of the right styloid process, the patient was seated in the right oblique position (about 15 degrees) with head bent to the right at an angle of about 10 degrees. The head was also extended about 10 degrees to bring the mandible out of the line of the styloid. The cassette was placed upon the patient's right shoulder and held firmly against the side of the neck and head by

Fig. 1. Lipiodol intravasation into the uterine venous plexus and the ovarian veins. The latter resemble ureters, being filled in their entirety, on the right side to the vena cava and on the left up to and including the renal vein.

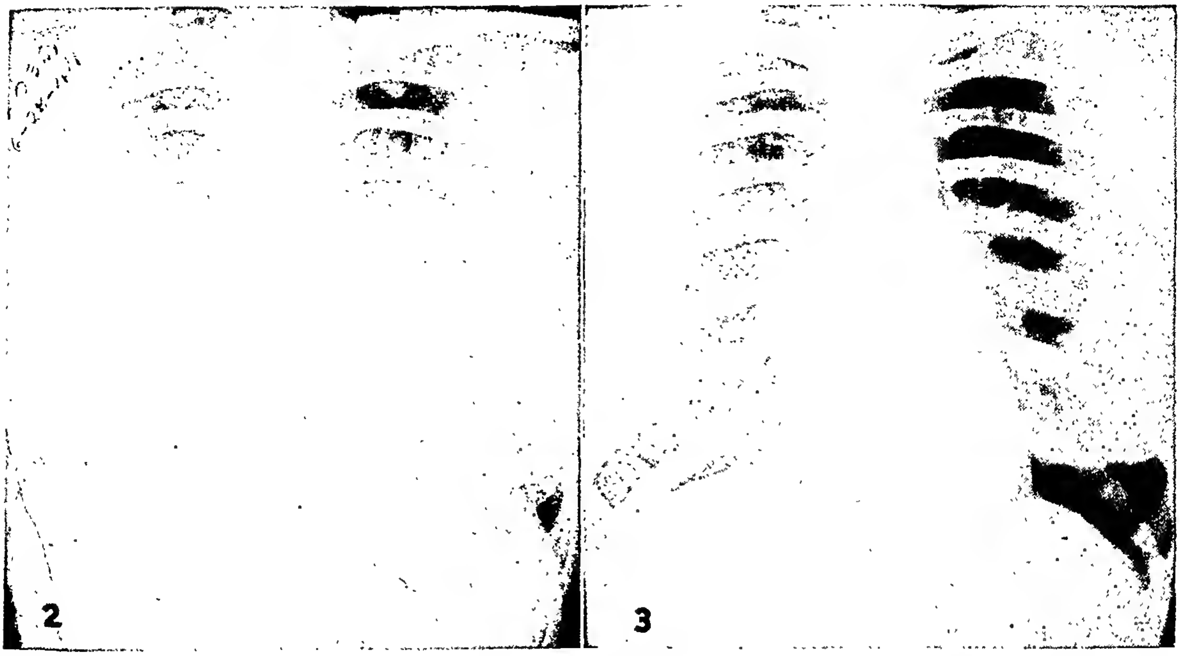
able to assume that the air, in this case, must have entered the tissues at the site of some trauma in the endometrium caused by the point of the uterine cannula. We mention these cases because we are aware that some gynecologists do not believe that in actual practice the endometrium can be thus damaged.

Many writers believe that intravasation may be caused by excessive pressure during the course of the injection and for this reason recommend that it be done under manometric control. In a poll among gynecologists, however, we have found no unanimity as to when pressure is to be considered excessive. Jarcho (8) recommends 150 mm. mercury, stating that tubes that do not open at this pressure must be considered as permanently closed. Most gynecologists whom we have questioned use a pressure of 180 to 200. Some, however, have used higher pressures, up to 300, routinely, without deleterious results. Some writers doubt whether in actual practice excessive pressure will, of itself, cause intravasation. Williams reported 3 cases in which the injection had been done under manometric control, presumably at a safe pressure. Moreover, Witwer and his co-workers (9) report a case of extensive intravasation in which the pressure was kept low under manometric control and every precaution was taken to avoid injury to the endometrium. Their subsequent experiments with extirpated uteri showed that occasionally intravasation could be obtained with injection under low pressure. These writers concluded that in some cases neither trauma nor excessive pressure is the potent cause of intravasation but that a third factor must be added, namely "an increased permeability of the 'receiving sinuses' such as is observed in idiopathic uterine bleedings."

Recent operation on the uterus, in particular a dilatation and curettage, has been considered as likely to favor intravasation. This is as we would expect, since a curettement would remove the protective layer of the mucosa and bring to the surface the underlying venous sinuses. Williams reported 2 cases of intravasation in which the injection had been done within seven days after a dilatation and curettage.

By analogy, one would expect that injection too soon after a menstrual period might also be predisposed to result in intravasation. The possibility must be considered as not unlikely that lipiodol injected under pressure before the endometrial lining has been restored, which is probably not before six to eight days after the end of menstruation, may enter the endometrial vessels. In 4 of Williams' cases of intravasation the injection had been done from two to four days after menstruation. In Lin's case, according to Walther, the injection had been done at a pressure of over 200, shortly after a period and under general anesthesia.

The amount of lipiodol used and the method of its introduction vary with different operators. Some writers advo-



Figs. 2 and 3. Figure 2 is a chest roentgenogram made nine days after uterosalpingography, showing a dense patchy opacity involving the lower two-thirds of both lungs. Figure 3, a roentgenogram made a month later, shows only an increased prominence of the peribronchial markings on the right side.

cate a fractional method of injection, using a preliminary amount of 1.5 to 2.0 c.c. Others give as high as 20 c.c. at an injection. Most gynecologists, we find, use 4 to 8 c.c. at one injection. The amount of lipiodol used probably has no bearing as a cause of intravasation. Where, however, intravasation does occur, the larger the amount injected the more likelihood there is of symptoms being produced.

CASE REPORT

Mrs. M. G., age 28, gave a history of instrumental abortion at the age of seventeen. In January 1941 she had a ruptured ectopic pregnancy of six weeks gestation, at which time the left tube was removed. The right tube appeared normal. In December 1941 Rubin tests done on two occasions were negative. The patient's general health was good except for frequent colds. Her last menstrual period previous to uterosalpingography was June 9–13, 1944. Lipiodol injection was done on June 19, in the morning. The usual technic was employed except that the amount injected, 15 c.c., was more than we ordinarily use. The ordinary pressure was used but without manometric control. No unusual difficulty was encountered.

On examining the film, we were surprised to find the bizarre picture shown in Figure 1. Not only was the cavity of the uterus filled, but its outer surface was visualized by contrast material within the venous plexus within and surrounding its walls. More spectacular, however, was the filling of the uterine and ovarian veins and their tributaries on both sides. The ovarian veins resembled ureters and were filled in their entirety, on the right side to the vena cava and on the left up to and including the renal vein. A film taken ten minutes later showed a decrease in the amount of lipiodol in all the veins.

The patient complained of more than the usual amount of abdominal discomfort and said she felt shaky and "jittery" but, after lying down for an hour, was able to go home. That afternoon a dry cough developed and in the evening the temperature rose to 102°. Physical examination showed only a few rhonchi throughout the chest. A film of the pelvis taken on the following day showed a lacy pattern of contrast material in the region of the uterus, suggesting the presence of some residual lipiodol within the smaller uterine veins. The right tube was filled. On the left side there was pooling either within a large varicosity of the ovarian vein or possibly in an extravasation within the broad ligament.

On the second day after the injection the patient felt sick. Her cough had increased in severity and she brought up bloody sputum Her temperature was 102.5°. On the third day the temperature had dropped to 101°. A film of the pelvis resembled that taken on the day after the injection. On the fourth day the temperature was normal and remained so thereafter. The cough persisted, however, and on June 28, nine days after uterosalpingography, a chest roentgenogram was obtained (Fig. 2). This showed a dense, patchy opacity involving both lungs below the 2d ribs. There were areas of con-

glomeration, especially on the right side, where the appearance was denser, but all of the lower two-thirds of the lungs appeared opacified to some extent The density was greater than that seen in the usual atypical pneumonia and it had a patternless, somewhat smeary appearance The clinical condition of the patient was surprisingly good, out of all proportion to the appearance of the chest film. One month later the chest was re-examined and on this occasion, aside from a slightly increased prominence of the peribronchial markings on the right side, the lungs were clear (Fig. 3).

The nature of the chest findings in this case is somewhat problematical. In the light of the clinical history we feel that it is reasonable to assume that the pathological changes were the result of lipiodol embolism. The nature of these lung changes is suggested by the experimental studies of Walther. From these we would deduce that the unusual pulmonary densities in our case may be attributable to various degrees of all of three factors, namely, residual phagocytosed lipiodol, perifocal pneumonitis about the emboli, and actual infarction.

It is felt that intravasation is not always avoidable even with the best technic, since its occurrence may depend upon intrauterine conditions beyond our knowledge. Certain measures designed to prevent it or limit its extent are, however, within our control and in this regard we feel that the following recommendations are appropriate.

(1) Injection for uterosalpingography should not be done earlier than six to eight days or later than ten days after completion of menstruation. The optimum period would seem to be eight to ten days after the menstrual period. It should not be performed in less than ten days after any operation on the uterus, in order to allow for complete healing.

(2) The position of the uterus should be determined by the use of a sound. When the cannula is inserted, it should be held, if necessary, at an angle that is calculated to make it parallel to the cervical canal, so that the tip of the cannula is not likely to be in contact with the endometrium. Williams recommends that the injection be done under fluoroscopic control both for ascertaining the position of the uterus and for early recognition of any intravasation. All roughness should, of course, be avoided. To this end, anesthesia is not only unnecessary but undesirable.

(3) In the presence of a normal endometrium we do not feel that the pressure likely to be needed will, by itself, cause intravasation. However, because of the possibility of a uterine mucosa of increased permeability, it is best to keep the pressure as low as is commensurate with proper filling of the uterus. A top pressure of 180 to 200 mm. mercury is safe and satisfactory in practically all cases, and we see no advantage in exceeding it. A manometer should be used for control of pressure and for purposes of record.

(4) The amount of lipiodol injected should be no more than is necessary to fill the uterus and tubes, with a slight spill. A satisfactory plan is to inject 4 to 6 c.c. and maintain pressure while the film is taken and developed. If more lipiodol is required, it can be injected subsequently. The preliminary injection of a small amount is important in that, if intravasation has occurred, it can be detected before a large amount of oil has entered the veins and hence is not likely to produce symptoms.

SUMMARY

Attention is drawn to lipiodol intravasation as a possible accident during uterosalpingography, and an illustrative case is reported. The factors involved in its production and the nature of associated pulmonary complications are discussed. Some suggestions are made as to how to avoid this accident.

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Bone Rarefaction After Skull Injuries[1]

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WE HAVE observed, several times in the past, areas of bone resorption in the skull following an injury, though in no instance was a connection between the trauma and the post-traumatic change unequivocably established. Recently, there have come to our attention, however, similar changes years after injury but with definite proof of the occurrence and nature of the antecedent trauma.

The object of this paper is to present three cases and to point out that one or more years after a skull injury—not necessarily a fracture—bone absorption and bone deposition may occur in the injured area, more particularly in younger persons. While we can present only a few cases, we believe that larger institutions will be able to throw the support of their rich material into the discussion of the problem here presented. Sir Thomas Lewis once said that it took him eleven years to find his first case of coarctation of the aorta, but only one year to find the next eleven cases.

Skull fractures and skull injuries are in many respects different from fractures and injuries of other bones of the body. They are set apart by the entirely different blood supply on the surface of the skull, the absence of an active circulation within the cranial bones, a unique bone structure which permits a fracture of the inner table without involvement of the outer table, and the slow healing of fracture lines with occasional replacement by fibrous tissue. It is of importance that the diploic veins are in connection with the veins of the galea as well as of the dura. The inner table, having its own blood supply, might well escape an absorptive process involving the outer table and the diploic wall.

The appearance of bone rarefaction a long time after injury, frequently accompanied by clinical symptoms and disability, is a familiar occurrence in other parts of the body, though it is little known in the bones of the skull. The considerable literature which has accumulated on the subject is accurately reviewed and discussed by E. S. King in his book on "Localized Rarefying Conditions of Bone." King classifies these rarefying conditions in two groups, diffuse and localized, but makes no mention of their occurrence in the skull. Many handbooks on skull fractures similarly fail to give any account of post-traumatic rarefaction of the cranial bones comparable to Kümmell's disease of the spine and the creeping substitution and aseptic necrosis observed in the carpus, tarsus, femur, humerus, and scaphoid, all having trauma as a common denominator.

Pancoast and Pendergrass, however, state that as a result of injury and presumably interference with the blood supply, an aseptic necrosis involving the diploe and the outer table may produce destruction of these portions of the calvaria. These necrotic areas may be either circumscribed or irregular, according to the type of injury. Translucent areas are frequently due to fibrotic tissue replacing the necrotic bone, or to a cystic development, as further sequelae of the traumatic lesion. These are sometimes diagnosed as "fibrosing osteitis." According to Pancoast and Pendergrass, the original fracture may at first be invisible, a "closed fracture," the fracture line appearing at a subsequent reexamination. In one of their cases of this type the pathological diagnosis following operation was "fibrosing osteitis of undetermined origin." Our Case II is another example of fibrotic substitution at the site

[1] From the Department of Roentgenology, Mount Sinai Hospital, Chicago, Ill. Accepted for publication in January 1945.

Figs. 1 and 2. Case I. Figure 1, the anteroposterior view, shows post-traumatic rarefaction of the tops of the parietal bones, with sclerotic ridge formation along the vertical part of the bones. Figure 2, the lateral view, shows the sharp demarcation toward the frontal and occipital bones. Over the top of the skull, only the inner table is preserved. The sagittal suture has not been spared.

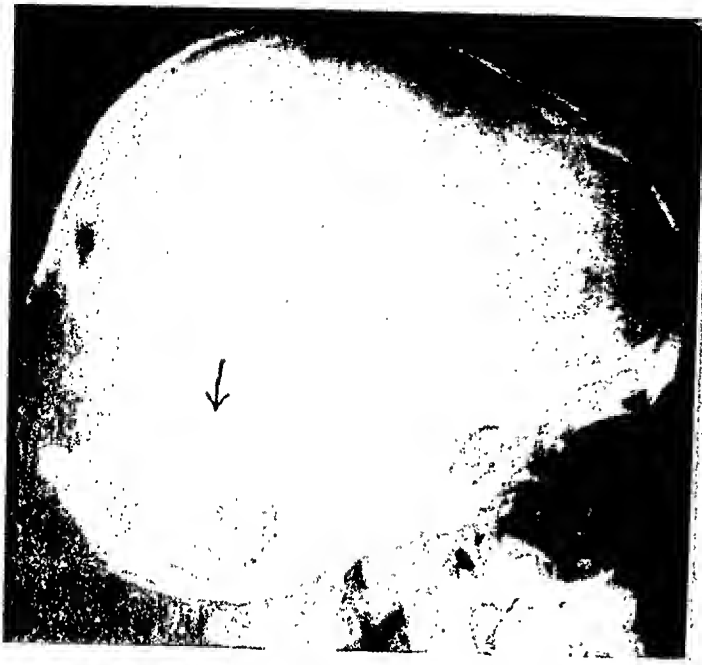
of a previous skull fracture, which may be designated as "fibrosing osteitis." Case I represents another stage of post-traumatic change, a sclerotic type of osteitis.

Thinning and thickening of skull bones are not pathologically opposed processes; bone deposition and bone absorption are active cellular processes, both depending on adequate blood supply and cellular activation. In inflammatory conditions, as well as in Paget's disease and other metabolic disturbances, we have a simultaneous appearance of osteoclastic activity and new bone formation. The first step in bone necrosis as it occurs post-traumatically in the skull, as elsewhere, is an interference with the blood supply. So long as it remains "architecturally intact," the damaged bone area will not show any abnormal x-ray signs, but when fibroblasts invade the necrotic area and it becomes revascularized, osteoclastic as well as osteoblastic cells appear and we have the picture either of an area of fibrous substitution, "fibrosing osteitis," or new bone formation, "sclerosing osteitis." The same circulatory conditions may lead to either.

A post-traumatic, pathological area in the skull may appear either as a translucent or as a sclerotic area, and it is not necessarily a depressed or linear fracture which leads to such a change. Finding such a circumscribed area in the x-ray picture, we should at least ask whether there is a history of trauma and take the possibility into differential diagnostic consideration. The medicolegal aspects are far reaching.

CASE REPORTS

CASE I: A woman 53 years of age, with no complaints of any kind, was told by her hairdresser that she had abnormal elevations and depressions of the skull and was urged to seek medical advice. A depression was palpable in either parietal bone, with irregular elevations and a marked prominence along the ridges. The examining physician (Dr. I. A. Rabins) ordered an x-ray study of the skull, and the unusual picture presented in Figures 1 and 2 was obtained. In the anteroposterior view (Fig. 1) the tops of the parietal bones are seen to be markedly thinned; in this area only the inner table remains, preserving the normal convexity of the skull. Had not the inner table been preserved, the skull would appear quadrangular rather than ovoid. The rarefying process extends over the sagittal suture but does not reach as far down as the squamous suture. It ends rather abruptly where the convexity of the top of the skull passes over into the vertical lateral wall. The lateral view (Fig. 2) shows a large segment of the top of the parietal bone to be rarefied, with a rather sharp demarcation against the frontal bone, the occipital bone, and the vertical portions of the parietals. These latter show a considerable sclerotic thickening.




Figs. 3 and 4. Case II. Figure 3 shows the large defect, with scalloped edges, in and above the left mastoid. Figure 4 is a close-up view of the defect after radiation therapy. No response to irradiation is evident.

Fig. 5. Case II. Film made four years before those reproduced above, following an accident, showing fracture line in the area of the defect.

This picture, calling to mind a derby hat crushed as its wearer passed through a low doorway, suggested a traumatizing force acting upon the skull from above. On questioning, the patient recalled an unusual accident. On a shopping tour as a bride, she was hit on the head with considerable force by a descending elevator of the old "pater noster" type. She was dazed and unconscious, but no skull fracture was diagnosed and the accident was forgotten. There were no pathological findings on clinical examination; blood calcium and phosphatase were normal. Encephalography was suggested but was refused.

CASE II: The patient was a child of 12 years. The mother had noticed a softened area behind the left ear, which gave a slight "cracking" sound on pressure. The examining physician confirmed this observation and found a slight sensitivity to pressure in the mastoid area. X-ray examination revealed a large, well defined defect behind the left ear above the mastoid, back of the sigmoidal sinus. The defect extended apparently through the entire thickness of the skull, showing scalloped edges (Figs. 3 and 4). Palpation disclosed a thin plate of bone which yielded to pressure and, like the membrane of a stethoscope, gave forth a "cracking" sound.

Here again there were no clinical findings of significance. The child had no fever, was in excellent condition, and behaved normally.

A multitude of diagnoses, especially Schüller-Christian disease, came to mind, but inquiry revealed a history of a skull injury four years previously. A film taken at that time showed clearly a fracture line going through the area (Fig. 5) of the defect. This line was no longer visible. On this basis the conclusion was reached that we were dealing with a post-traumatic rarefaction, and aspiration biopsy was suggested.

The neurologist (Dr. Eric Oldberg) was convinced that this was quite definitely a post-traumatic rarefaction and added, in his report, that he had previously seen such changes following trauma, especially in children. He suggested x-ray therapy.

Figs. 6 and 7. Case III. Figure 6 shows grooved thinning of both parietal bones believed to be of developmental origin, though this patient had suffered severe injury in an accident fifteen years previously. Figure 7, the lateral view, shows the segmental rarefaction of the parietal bones.

CASE III: This case is more contestable than Cases I and II, and is added here as illustrative of the differential diagnostic difficulties. The patient was a white woman 56 years old, perfectly well, with no headaches or other symptoms referable to the skull. The history is similar to that in Case I, the elevations and depressions of the skull having been discovered by a daughter who was dressing the patient's hair. A physician (Dr. Dolnik) was consulted and x-ray examination was ordered. The film (Fig. 6) shows a type of grooved thinning of the parietal bones with bone of normal thickness and structure around the sagittal suture. The lateral view (Figs. 7 and 8) show a segmental rarefaction of the parietal bone with a demarcation zone of increased diameter. The roentgenologic diagnosis was "grooved type of parietal thinness of developmental origin, as described by Camp and Nash."

The patient, however, called our attention to an accident sustained fifteen years earlier, when her car overturned and she was thrown into a ditch. She was unconscious, but no x-ray picture of the skull was taken; she had, however, a fractured clavicle and many bruises. In contrast to Case I, this case demonstrates, at least roentgenologically, what is in our opinion the typical picture of parietal thinness sparing the sagittal suture, which was involved in Case I. At least, the grooved type of parietal thinness is known never to reach the sagittal suture. Furthermore, the pronounced sclerotic reaction seen in Case I is absent here.

Fig. 8. Case III. Close contact view of marginal area.

Taking into account that localized thickening of the skull, especially of the parietal bones, is frequently due to subperiosteal hemorrhage, we are tempted to ask whether some cases of parietal thinning are not also due to trauma. Parietal thinning has been found not only in older persons, but also in children, at least one instance being reported in a child of four. Such trauma might be in the form of a birth injury, for example, disturbing the normal balance between bone absorption and bone restitution which goes on throughout life. Biparietal blood extravasation, as seen in

EDITORIAL

The Origin of Cancer in Man

Recent work in the field of neoplasms further emphasizes the fact, long apparent, that no one cause will be found for the development of cancer in man. Already a number of agents are known to produce cancer directly or indirectly. Scrotal cancer in chimney sweeps gave the clue over 150 years ago for the long series of investigations that finally has produced the wide range of hydrocarbons proved to be carcinogenic for mice and some other animals. Among substances known to produce human cancer, shale oil, arsenic, and certain naphthylamine compounds have been well recognized. Radiologists are all too familiar with induction of carcinoma by long-continued roentgen or radium irradiation. Similarly, the hazard of leukemia as a result of chronic exposure to radiation has been established. A wide range of carcinogenic agents met with in various occupations have been studied by Hueper.

One of the astonishing features of many carcinogenic agents thus far worked with has been their high degree of specificity for various animals. Thus hydrocarbons extremely potent in the mouse sometimes are non-effective in the rabbit and other species of animals tested. In general, it can be stated that, with the exception of coal tar, some of the petroleum fractions and some of the physical agents, there are few substances which can be regarded as potential carcinogens for all species. Whether this variation hinges on ability of the animal to detoxify the various compounds or on a failure of the agent to produce the requisite type of tissue injury has not yet been clarified. The fact that some of the carcinogenic hydrocarbons are shown to be hydroxylated in the rabbit to a non-effective form suggests that detoxification may be a factor.

The carcinogenic effect of excessive ultraviolet radiation or insolation has been clearly brought out by the data bearing on the occurrence of skin cancer in southern and dry climates. Ultraviolet radiation is carcinogenic in experimental animals also.

The role of heredity, established as important in the genesis of animal tumors, has not yet been clearly defined in man, chiefly because no adequate data for studies of heredity have been available. In animals, particularly mice, intensive inbreeding has produced strains likely or unlikely to develop cancer of a given type. Such hereditary tendency may, however, be profoundly altered by a "milk factor." This substance, found in the milk of adult mice, is effective to a high degree in transmitting by ingestion to young mice the cancer tendency of the foster mother.

While the modes of origin of the majority of tumors in man are as yet not clearly determined, certainly contagion or infection can be effectively ruled out. No adequate evidence has yet been found to suggest incrimination of any bacterium or animal parasite as a causative agent for cancer. While certain tumors such as infectious lymphosarcoma in dogs, leukemia and endothelioma in fowls, papilloma and epidermoid carcinoma in rabbits, may be transmitted by a virus, no convincing evidence of viral origin of any human neoplasm has been produced.

Trauma has often been discussed as a possible cause of cancer. There is no doubt that it has been considered an effective agent far more often than it has proved to be one. Practically all the evidence is along the lines of the *post hoc ergo propter hoc* fallacy. In general, it can be said that there is no satisfactory evidence that carcinoma arises as a result of single

trauma. There are some instances in which sarcoma has followed single trauma with startling coincidence if not actually on an etiologic basis. The minimal criteria accepted by most authorities at the present time are as follows: (*a*) that previous integrity of the part should be established; (*b*) that adequacy of trauma should be established; (*c*) that a reasonable time interval should elapse between trauma and the appearance of tumor; (*d*) that the tumor should be of a type reasonably derived from cells of that part.

By and large, the various agents that produce cancer in man have an injurious effect as well as or in place of a stimulating effect, and it is very likely that increased cellular proliferation with or without mutation is an important factor in the appearance of human cancer.

The cell mutation theory of the origin of cancer has received considerable support from certain types of experimental production of cancer as well as from what we know of cell behavior in general. In particular, mutations induced by radiation through chromosomal injury have been of striking importance. The precancerous character of radiation changes induced in skin and other tissues has been all too clearly proved by our past experience. In general, it can be stated that those conditions that lead to long attempted repair with correlated proliferation of cells and repeated mitotic activity rather predispose to the chance of development of malignant growth. Chronic irritation with associated repair has long been considered as a responsible cause of cancer, and few malignant tumors in humans arise in previously intact tissue.

There is evidence that abnormalities of estrogenic hormonal balance may be participating factors in the causation of some tumors, particularly those of the breast and uterus.

No editorial on cancer in man would be complete without calling attention to the fact that all cancer research up to the present time has been on a shoestring scale. Research grants have all too often been in the range of $500 to $1,500 and made on an annual basis. Such support places a premium on nibbling at minor angles of the problem and neglecting significant but costly and time-consuming avenues of investigation. When we think that we can afford to spend two billion dollars and concentrate over a hundred thousand men to produce two bombs capable of killing or wounding over 300,000 human beings, the utter inadequacy of the present support of cancer research is only too apparent.

SHIELDS WARREN, M.D.

Dangers Inherent in Scattered Cathode Rays

An incident which occurred in the Department of Radiology of the Massachusetts General Hospital in December 1944 is particularly pertinent at the present time, inasmuch as it has to do with burns caused by scattered cathode rays. Six men, after very brief exposure to scattered electrons from a 1,200-kv. electrostatic generator which was under repair, experienced burns of varying severity. These burns had certain similarities to, but differed from, x-ray reactions, sunburn, and thermal burns. Certain factors characterized them, one being an apparently limited depth of penetration. The burns showed three distinct phases, the later phases making their appearance as the earlier ones were healing. The second and third phases developed both in areas previously uninvolved and in old healing areas.

The extent of scattering of cathode rays had not been appreciated, nor had the medical literature contained articles dealing with that phase of cathode irradiation. In order that this experience at the Massachusetts General Hospital may not be duplicated, publication of a detailed account seems necessary. This report will appear in the January 1946 issue of RADIOLOGY.

THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

The Thirty-first Annual Meeting of the Radiological Society of North America was held at the Drake Hotel, Chicago, Nov. 9 and 10, being limited to business sessions and the annual banquet. At the banquet announcement was made of the new officers; Dr. Lewis G. Allen made the presidential address and passed on to his successor, Dr. Lowell S. Goin, the Pfahler gavel. Among the guests were two representatives of the Inter-American Congress of Radiology, who extended to members of the Radiological Society a cordial invitation to attend the meeting in Habana, Nov. 17–22, 1946.

Dr. R. R. Newell had been chosen as the Carman lecturer. His lecture on "The Quality of Radiation," was not delivered but will appear in an early issue of RADIOLOGY.

The new officers of the Society are: President, Lowell S. Goin, M.D.; President-Elect, Frederick W. O'Brien, M.D.; 1st Vice-President, Paul C. Swenson, M.D.; 2d Vice-President, Wendell G. Scott, M.D.; 3d Vice-President, Ralph G. Willy, M.D.; Secretary-Treasurer, Donald S. Childs, M.D.; Librarian, Howard P. Doub, M.D. The newly elected member to the Board of Directors is John S. Bouslog, M.D.

AMERICAN COLLEGE OF RADIOLOGY OBSERVES THE FIFTIETH ANNIVERSARY OF RÖNTGEN'S DISCOVERY

On Nov. 8, 1945, fifty years from the very day on which Röntgen is believed first to have demonstrated the x-rays in his Würzburg laboratory, a banquet in commemoration of that significant discovery was held in Chicago under the joint auspices of the Commission on Public Relations of the American College of Radiology and the National Electrical Manufacturers Association. Some 900 persons were in attendance, including many who were in Chicago for meetings of the several national radiological societies.

Dr. Lowell S. Goin, President of the College, presided, and the principal address of the evening was given by Dr. Robert S. Stone. Dr. Stone spoke on "Radiology from Röntgen to the Eve of Atomic Energy," a subject on which his broad experience as a radiologist and his work as one of the group of scientists participating in the development of the atomic bomb enabled him to speak with special authority. Mr. A. C. Streamer, President of the National Electrical Manufacturers Association spoke on behalf of that organization and at 10:30 the guests heard the Association's national broadcast arranged in honor of Röntgen's great contribution to science and to humanity. President Truman's greetings were conveyed through a letter addressed to Mr. Mac Cahal, Executive Secretary of the American College of Radiology.

Dr. Warren W. Furey, President of the Chicago Roentgen Society, was chairman of the Committee on Arrangements, and the success of the occasion speaks eloquently of his efficient planning.

NEW ENGLAND ROENTGEN RAY SOCIETY

The New England Roentgen Ray Society observed the fiftieth anniversary of the discovery of x-rays at its meeting at the Harvard Club, Boston, Nov. 16, with a special program. The speakers were: Wm. J. Elliott, M.D., of Memorial Hospital, Worcester, Mass., on "The Use of X-Rays in Art"; Paul E. Tivnan, M.D., of Beverly Hospital, Beverly, Mass., on "Some Industrial Applications of X-Rays"; Joseph T. Walker, Ph.D., of the Massachusetts Department of Public Safety, on "The Application of X-Rays to Crime Detection"; Bertram E. Warren, Sc.D., Professor of Physics, Massachusetts Institute of Technology, on "X-Rays as a Tool of the Physicist"; Merrill C. Sosman, M.D., Clinical Professor of Radiology, Harvard Medical School, on "X-Rays in Medicine."

TEXAS RADIOLOGICAL SOCIETY

The recently elected President and Secretary of the Texas Radiological Society are Dr. Tom B. Bond and Dr. R. P. O'Bannon, both of Fort Worth. The next meeting of the Society will be held in Dallas on Jan. 14, 1946.

THE DETROIT ROENTGEN RAY AND RADIUM SOCIETY

The Detroit Roentgen Ray and Radium Society celebrated the anniversary of the discovery of the x-rays at its meeting on Nov. 1. The speaker of the evening was Dr. Otto Glasser, of Cleveland, whose intimate knowledge of Röntgen gave special interest to his remarks. It was a source of satisfaction on this occasion to hear that Röntgen's laboratory at Würzburg and his home at Lannep escaped damage during the bombings of Germany.

SECOND MEXICAN CONGRESS OF CANCER

The Second Mexican Congress of Cancer and Third Medical Week of the Occident will be held in the city of Guadalajara, Feb. 3–9, 1946. A special invitation to attend has been extended to members of the Radiological Society of North America.

DR. ANNETTE FEASTER HONORED

Dr. Annette M. Feaster, of St. Petersburg, Fla., has recently assumed the presidency of the Pinellas County Medical Society, the first woman to hold that office. Dr. Feaster is a diplomate of the American Board of Radiology and a member of the Radiological Society of North America. She is associated in the practice of radiology with her husband, Dr. O. O. Feaster.

REGIONAL COURSE ON CANCER

The first of a projected series of regional postgraduate courses to be sponsored by the commission on education of the American College of Radiology in conjunction with selected teaching institutions will be conducted during the week of Feb. 4 at the Philadelphia County Medical Society Building. This first and experimental course will be jointly sponsored by the College and the Philadelphia Roentgen Ray Society. Topics to be discussed include:

Feb. 4: Practical consideration of therapy problems concerned with the physics of radium and roentgen rays.

Feb. 5: Carcinoma of the female genital tract.

Feb. 6: Carcinoma of the breast.

Feb. 7: Carcinoma of the head and neck.

Feb. 8: Carcinoma of the skin and treatment of infections.

Feb. 9: Radiation treatment of blood dyscrasias and lymphoblastoma. Cancer detection clinics and important developments in cancer research.

The pathologic, clinical, and therapeutic aspects of the conditions under consideration will be covered and a round-table discussion of practical problems will be conducted. Teachers will be drawn from the fields of radiotherapy, surgery, oncology, physics, biophysics, and pathology. Advance registration may be made by writing to the Commission on Education of the American College of Radiology, 20 North Wacker Drive, Chicago 6.

In Memoriam

CHARLES BURDETTE PILLSBURY, M.D.

1893–1945

Dr. Charles Burdette Pillsbury, a member of the Radiological Society of North America, died Sept. 11, 1945, in Ypsilanti, Mich., after a brief illness.

Dr. Pillsbury was born in Duluth, Minn., May 22, 1893, and received his preliminary education in the Duluth public schools. His premedical education was obtained at the University of Minnesota, from which he entered the University of Michigan Homeopathic Medical School. Following his graduation in 1918, he was in charge of the X-Ray Department of the Homeopathic Hospital in Ann

Charles Burdette Pillsbury, M.D.

Arbor. In 1921 he opened an office in Ypsilanti, where he devoted himself to the practice of roentgenology and industrial medicine. Subsequently he gave practically all of his time to the former specialty. He was roentgenologist to Bayer Memorial Hospital and Ypsilanti State Hospital, both of Ypsilanti.

Dr. Pillsbury was past president of the Washtenaw County (Michigan) Medical Society. He was a diplomate of the American Board of Radiology, a member of the Michigan Association of Roentgenologists, the Detroit Roentgen-Ray and Radium Society, the American College of Radiology, and Alpha Sigma Homeopathic Medical Fraternity. He was active in the American Legion and the Isaac Walton League.

GLENN W. FILES

1897–1945

Glenn W. Files, director of the Technical Service Department of General Electric X-Ray Corporation since 1934, and a member of that firm for twenty-six years, died in Chicago, on Sept. 11, at the age of forty-eight.

Mr. Files was born on Jan. 17, 1897, in Winfield, Kansas, and did his first work as a technician for a physician in that community. In World War I, he was a sergeant in the U. S. Army, serving in France as an x-ray instructor and technician. Following

Glenn W. Files

the war, he joined the Victor X-Ray Corporation, predecessor of General-Electric X-Ray Corporation, as an instructor under Dr. E. C. Jerman, director of the Education Department, whom he later succeeded in that position.

Mr. Files played an important part in the development of x-ray technic and instructional methods. He assisted in the publication of "Modern X-Ray Technic" (1928) and "X-Ray Studies and Advanced Radiographic Technic" (1931), edited by Dr. Jerman, and was himself editor in chief of "Medical Radiographic Technic," published in 1943. He was one of the founders of the American Society of X-Ray Technicians.

Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

CLASSIC DESCRIPTIONS OF DISEASE, WITH BIOGRAPHICAL SKETCHES OF THE AUTHORS. By RALPH H. MAJOR, M.D., Professor of Medicine, University of Kansas School of Medicine. A volume of 679 pages, with 158 illustrations. Published by Charles C Thomas, Springfield, Ill. Third edition, 1945. Price $6.50.

A TEXTBOOK OF SURGERY. By JOHN HOMANS, M.D., Clinical Professor of Surgery, Emeritus, Harvard Medical School. Compiled from Lectures and Other Writings of Members of The Surgical Department. With a Special Bibliographical Index and with illustrations by Willard C. Shepard and others. A volume of 1278 pages, with 530 figures. Published by Charles C Thomas, Springfield, Ill. Sixth Edition, 1945. Price $8.00.

THE OSSEOUS SYSTEM. A HANDBOOK OF ROENTGEN DIAGNOSIS. By VINCENT W. ARCHER, M.D., Professor of Roentgenology, University of Virginia Department of Medicine. A volume of 320 pages, with 148 plates. Published by The Year Book Publishers, Inc., 304 South Dearborn St., Chicago 4, 1945. Price $5.50.

Book Reviews

PEDIATRIC X-RAY DIAGNOSIS. A TEXTBOOK FOR STUDENTS AND PRACTITIONERS OF PEDIATRICS, SURGERY AND RADIOLOGY. By JOHN CAFFEY, A.B., M.D., Associate Professor of Pediatrics, College of Physicians and Surgeons, Columbia University; Associate Pediatrician and Roentgenologist, Babies Hospital and Vanderbilt Clinic, New York City; Consulting Pediatrician, Grasslands Hospital, Westchester County, N. Y., and St. John's Hospital, Yonkers, N. Y. A volume of 838 pages, with 711 illustrations. Published by The Year Book Publishers, Inc., 304 S. Dearborn St., Chicago 4, 1945. Price $12.50.

In Dr. Caffey's "Pediatric X-Ray Diagnosis," we have the answer, long deferred, to the need of an authoritative up-to-date text on the roentgenologic diagnosis of children's diseases. This is the first textbook on this subject to be printed in English in the past thirty-five years.

The author has arranged his material in six main divisions: (1) The Head and Neck; (2) The Thorax; (3) The Abdomen and Gastro-Intestinal Tract; (4) The Pelvis and Genito-Urinary Tract; (5) The Extremities; (6) The Vertebral Column. Under each of these headings, he describes the normal anatomy as disclosed roentgenologically, together with the commonly observed variations. The descriptions of disease processes, though they may appear in some instances to be rather brief, cover the essential points in excellent fashion and demonstrate the mature judgment of the writer. Bibliographic references are supplied at appropriate points, and a useful index is furnished.

The text is well illustrated with reproductions of films from the files of the Babies Hospital, New York, with which the author is associated, and by schematic drawings. The type is clear and readable and the paper and binding are of excellent quality.

To use the language of the day, the book is a "natural." It is difficult to see how any roentgenologist can afford to be without it.

RADIOLOGICAL SOCIETIES OF NORTH AMERICA

Editor's Note.—Will secretaries of societies please co-operate by sending information to Howard P. Doub, M.D., Editor, Henry Ford Hospital, Detroit 2, Mich.

UNITED STATES

Radiological Society of North America.—Secretary, D. S. Childs, M.D., 607 Medical Arts Bldg., Syracuse 2, N.Y.

American Roentgen Ray Society.—Secretary, Harold Dabney Kerr, M.D., Iowa City, Iowa.

American College of Radiology.—Secretary, Mac F. Cahal, 20 N. Wacker Dr., Chicago 6, Ill.

Section on Radiology, American Medical Association.—Secretary, U. V. Portmann, M.D., Cleveland Clinic, Cleveland 6, Ohio.

ARKANSAS

Arkansas Radiological Society.—Secretary, J. S. Wilson, M.D., Monticello. Meets every three months and annually at meeting of State Medical Society.

CALIFORNIA

California Medical Association, Section on Radiology.—Secretary, Gordon King, M.D., Children's Hospital, San Francisco.

Los Angeles County Medical Association, Radiological Section.—Secretary, Roy W. Johnson, M.D., 1407 South Hope St., Los Angeles. Meets second Wednesday of each month at County Society Building.

Pacific Roentgen Society.—Acting Secretary, Frederick H. Rodenbaugh, M.D., 490 Post St., San Francisco. Meets annually with California Medical Association.

San Diego Roentgen Society.—Secretary, Henry L. Jaffe, M.D., U. S. Naval Hospital, San Diego, Calif. Meets first Wednesday of each month.

San Francisco Radiological Society.—Secretary, Carlton L. Ould, University Hospital, Medical Center, San Francisco 22. Meets monthly on the third Thursday at 7:45 P.M., first six months of the year in Lane Hall, Stanford University Hospital, and second six months in Toland Hall, University of California Hospital.

COLORADO

Denver Radiological Club.—Secretary, A. Page Jackson, Jr., M.D., 304 Republic Bldg., Denver 2. Meetings third Friday of each month, Denver Athletic Club.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Secretary, Max Climan, M.D., 242 Trumbull St., Hartford 3. Meetings bimonthly, second Thursday.

FLORIDA

Florida Radiological Society.—Secretary-Treasurer, J. F. Pitman, M.D., Blanche Hotel Annex, Lake City.

GEORGIA

Georgia Radiological Society.—Secretary-Treasurer, James J. Clark, M.D., 478 Peachtree St., N. E., Atlanta 3. Meets in November and at the annual meeting of State Medical Association.

ILLINOIS

Chicago Roentgen Society.—Secretary, Fay H. Squire, M.D., 1753 W. Congress St., Chicago 12. Meets at the Palmer House, second Thursday of October, November, January, February, March, and April.

Illinois Radiological Society.—Secretary-Treasurer, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—Secretary, Frank S. Hussey, M.D., 250 East Superior St., Chicago 11.

INDIANA

The Indiana Roentgen Society.—Secretary-Treasurer, Harold C. Ochsner, M.D., Methodist Hospital, Indianapolis 7. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Secretary, Arthur W. Erskine, M.D., Suite 326 Higley Building, Cedar Rapids. Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—Secretary-Treasurer, Sydney E. Johnson, 101 W. Chestnut St., Louisville.

LOUISIANA

Louisiana Radiological Society.—Secretary-Treasurer, Johnson R. Anderson, M.D., North Louisiana Sanitarium, Shreveport. Meets annually at same time as State Medical Society.

Shreveport Radiological Club.—Secretary, Oscar O. Jones, M.D., 2622 Greenwood Road. Meets monthly September to May, third Wednesday, 7:30 P.M.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Secretary, Charles N. Davidson, M.D., 101 West Read St., Baltimore 1.

MICHIGAN

Detroit X-ray and Radium Society.—Secretary-Treasurer, E. R. Witwer, M.D., Harper Hospital, Detroit 1. Meetings first Thursday of each month from October to May, at Wayne County Medical Society club rooms.

Michigan Association of Roentgenologists.—Secretary, Bruce MacDuff, M.D., 201 Sherman Bldg., Flint 3.

MINNESOTA

Minnesota Radiological Society.—Secretary, A. T. Stenstrom, M.D., Minneapolis General Hospital, Minneapolis 26. Meetings quarterly.

MISSOURI

Radiological Society of Greater Kansas City.—Secretary, John W. Walker, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Friday of each month.

St. Louis Society of Radiologists.—Secretary, Edwin C. Ernst, M.D., 100 Beaumont Medical Bldg. Meets on fourth Wednesday of each month except June, July, August, and September.

NEBRASKA

Nebraska Radiological Society.—Secretary-Treasurer, Donald H. Breit, M.D., University of Nebraska Hospital, Omaha 5. Meetings third Wednesday of each month at 6 P.M. in either Omaha or Lincoln.

NEW ENGLAND

New England Roentgen Ray Society.—Secretary-Treasurer, George [illegible] D., Massachusetts Memorial Hos-

pitals, Boston, Mass. Meets monthly on third Friday at Boston Medical Library.

NEW HAMPSHIRE

New Hampshire Roentgen Society.—Secretary-Treasurer, Richard C. Batt, M.D., St. Louis Hospital, Berlin.

NEW JERSEY

Radiological Society of New Jersey.—Secretary, H. R. Brindle, M.D., 501 Grand Ave., Asbury Park. Meetings at Atlantic City at time of State Medical Society and midwinter in Newark as called.

NEW YORK

Associated Radiologists of New York, Inc.—Secretary, William J. Francis, M.D., East Rockaway, L. I.

Brooklyn Roentgen Ray Society.—Secretary-Treasurer, Leo A. Harrington, M.D., 880 Ocean Ave., Brooklyn 26. Meets fourth Tuesday of every month, October to April.

Buffalo Radiological Society.—Secretary-Treasurer, Joseph S. Gian Franceschi, M.D., 610 Niagara St., Buffalo 1. Meetings second Monday evening each month, October to May, inclusive.

Central New York Roentgen Society.—Secretary-Treasurer, Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse 10. Meetings in January, May, and October.

Long Island Radiological Society.—Secretary, Marcus Wiener, M.D., 1430 48th St., Brooklyn 19. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—Secretary, Wm. Snow, M.D., 941 Park Ave., New York 28.

Rochester Roentgen-Ray Society.—Secretary, Murray P. George, M.D., 260 Crittenden Blvd., Rochester 7. Meets at Strong Memorial Hospital, third Monday, September through May.

NORTH CAROLINA

Radiological Society of North Carolina.—Secretary-Treasurer, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meets in May, and October.

NORTH DAKOTA

North Dakota Radiological Society.—Secretary, Charles Heilman, M.D., 1338 Second St., N., Fargo.

OHIO

Ohio Radiological Society.—Secretary, Henry Snow, M.D., 1061 Reibold Bldg., Dayton 2. Next meeting at annual meeting of the Ohio State Medical Association.

Cleveland Radiological Society.—Secretary-Treasurer, Carroll C. Dundon, M.D., 2065 Adelbert Road, Cleveland 6. Meetings at 6:30 P.M. on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).*—Secretary-Treasurer,* Samuel Brown, M.D., 707 Race St., Cincinnati 2. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—Secretary-Treasurer, L. E. Wurster, M.D., 416 Pine St., Williamsport 8. The Society meets annually.

Philadelphia Roentgen Ray Society.—Secretary, Calvin L. Stewart, M.D., Jefferson Hospital, Philadelphia 7. Meets first Thursday of each month at 8:00 P.M., from October to May, in Thomson Hall, College of Physicians, 21 S. 22d St.

Pittsburgh Roentgen Society.—Secretary-Treasurer, Lester M. J. Freedman, M.D., 4800 Friendship Ave., Pittsburgh 24. Meets second Wednesday of each month at 6:30 P.M., October to May, inclusive, at The Ruskin, 120 Ruskin Ave.

ROCKY MOUNTAIN STATES

Rocky Mountain Radiological Society (North Dakota, South Dakota, Nebraska, Kansas, Texas, Wyoming, Montana, Colorado, Idaho, Utah, New Mexico).*—Secretary,* A. M. Popma, M.D., 220 North First St., Boise, Idaho.

SOUTH CAROLINA

South Carolina X-ray Society.—Secretary-Treasurer, Robert B. Taft, M.D., 103 Rutledge Ave., Charleston 16.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—Secretary-Treasurer, J. Marsh Frère, M.D., 707 Walnut St., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Dallas-Fort Worth Roentgen Study Club.—Secretary, R. P. O'Bannon, M.D., 650 Fifth Ave., Fort Worth, 4. Meetings on third Monday of each month, in Dallas in the odd months and in Fort Worth in the even months.

Texas Radiological Society.—Secretary-Treasurer, Asa E. Seeds, M.D., Baylor Hospital, Dallas.

VIRGINIA

Virginia Radiological Society.—Secretary, E. Latané Flanagan, M.D., 215 Medical Arts Bldg., Richmond 19.

WASHINGTON

Washington State Radiological Society.—Secretary-Treasurer, Thomas Carlile, M.D., 1115 Terry Ave., Seattle. Meetings fourth Monday of each month, October through May, at College Club, Seattle.

WISCONSIN

Milwaukee Roentgen Ray Society.—Secretary-Treasurer, C. A. H. Fortier, M.D., 231 W. Wisconsin Ave., Milwaukee 3. Meets monthly on second Monday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, S. R. Beatty, M.D., 185 Hazel St., Oshkosh. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society in September.

University of Wisconsin Radiological Conference.—Meets first and third Thursdays, 4 to 5 P.M., September to May, inclusive, Room 301, Service Memorial Institute, 426 N. Charter St., Madison 6.

CANADA

Canadian Association of Radiologists.—Honorary Secretary-Treasurer, J. W. McKay, M.D., 1620 Cedar Ave., Montreal.

La Société Canadienne-Française d'Electrologie et de Radiologie Médicales.—General Secretary, Origène Dufresne, M.D., Institut du Radium, Montreal. Meets on third Saturday of each month.

CUBA

Sociedad de Radiología y Fisioterapia de Cuba.—Offices in Hospital Mercedes, Havana. Meets monthly.

ABSTRACTS OF CURRENT LITERATURE

ROENTGEN DIAGNOSIS

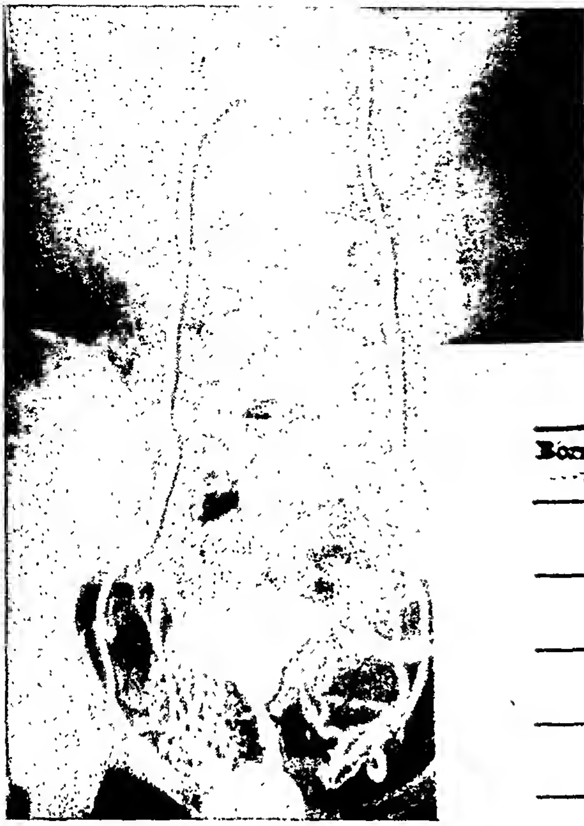


Fig. 1. Lipiodol intravasation into th nous plexus and the ovarian veins. The la ureters, being filled in their entirety, on t to the vena cava and on the left up to a the renal vein.

able to assume that the air, in must have entered the tissues a of some trauma in the end caused by the point of the uterin We mention these cases becau aware that some gynecologists d lieve that in actual practice t metrium can be thus damaged.

Many writers believe that intr may be caused by excessive pressu the course of the injection and reason recommend that it be do manometric control. In a pol gynecologists, however, we have unanimity as to when pressure is considered excessive. Jarcho (8) recommends 150 mm. mercury, stating that tubes that do not open at this pressure must be considered as permanently closed. Most gynecologists whom we have questioned use a pressure of 180 to 200. Some, however, have used higher pressures, up to 300, routinely, without deleterious re Some writers doubt whether in a practice excessive pressure will, of cause intravasation. Williams repor cases in which the injection had been under manometric control, presumab a safe pressure. Moreover, Witwe his co-workers (9) report a case of exte intravasation in which the pressure kept low under manometric

been done from two to four days afte menstruation. In Lin's case, according t Walther, the injection had been done at a pressure of over 200, shortly after a perio and under general anesthesia.

The amount of lipiodol used and the method of its introduction vary with different operators. Some writers advo-

Spontaneous Mediastinal Emphysema with Pneumothorax Simulating Organic Heart Disease. Henry Miller. Am. J. M. Sc. 209: 211–220, February 1945.

Four cases of spontaneous mediastinal emphysema associated with a left pneumothorax are described. The history and physical and electrocardiographic findings simulated those of organic heart disease.

Macklin (Canad. M. A. J. 36: 414, 1937; Arch. Int. Med. 64: 913, 1939; J. Michigan M. Soc. 39: 756, 963, 1940) showed the probable mechanism of spontaneous mediastinal emphysema by demonstrating that air enters the perivascular sheaths of the pulmonary vessels, presumably through ruptures in the alveolar walls. This air eventually breaks through into the mediastinum. By the formation of large blebs along the vessels, the pulmonary circulation may be impeded. The air may extend from the perivascular sheaths into the connective tissues and dissect a path toward the pleura, where a subpleural bleb may be formed. While a pneumothorax could be produced by rupture of an emphysematous subpleural bleb, Macklin more commonly found a rent in the mediastinal wall which allowed access of air to the pleural cavity. From the mediastinum the air will follow the fascial planes into the neck, chest wall, about the pericardium, or retroperitoneally.

The onset of spontaneous mediastinal emphysema is characterized by the sudden development of precordial or substernal pain, which may radiate to the back, shoulder, neck, or left arm. The pain may last from several hours to several days. This pain must be differentiated from that of coronary occlusion, dissecting aneurysm, pericarditis, and pulmonary embolism.

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Most of the cases have been found in relatively young patients. In 3 of the cases described by the author there were electrocardiographic changes simulating those of myocardial damage. The other cases reported in the literature showed no such abnormalities.

BENJAMIN COPLEMAN, M.D.

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LEWIS G. JACOBS, M.D.

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One typical case of alveolar-cell carcinoma of the lung and two others which meet the essential clinicopathologic criteria of this tumor are presented, bringing the total cases recorded in the literature to not more than 50. There are a few pertinent clinical and pathologic considerations common to the three cases which distinguish this tumor from the usual pulmonary cancer. All three patients were women in the fifth decade; the course of the illness, from initial symptoms to death, was relatively short, being approximately seven months, five weeks, and seven months, respectively. In the second case symptoms referable to the lungs were absent throughout the illness, while in the third case, respiratory difficulties were encountered only in the last four weeks of life. In all of the cases, the roentgenogram of the chest was of the utmost assistance. It alone led to the discovery of extensive involvement of the lungs, altogether unsuspected, in Cases 2 and 3, but was interpreted as representing a metastatic miliary carcinoma. In the third case, because of a mass at the right upper hilum, a diagnosis of bronchiogenic carcinoma was finally made. Cough was not a prominent or constant feature; in none of the cases was bloody sputum recorded.

Roentgenologic Appearance and Pathology of Intrapulmonary Lymphatic Spread of Metastatic Cancer. H. Peter Mueller and Ronald C. Sniffen. Am. J. Roentgenol. 53: 109–123, February 1945.

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In general, this diffuse infiltrative type of metastasis occurs in younger persons, the majority of cases being seen between the ages of thirty and forty-nine. The important clinical findings are dyspnea, cyanosis, a productive cough, and rapid cachexia. The roentgen manifestations appear to be due to masses of tumor cells within dilated lymphatics around bronchi and blood vessels. In differential diagnosis, miliary tuberculosis, pulmonary congestion and edema, pneumoconiosis, sarcoid, primary fibrosis with emphysema, and atypical pneumonia must be considered. In the individual case a definite diagnosis may be difficult unless there are other roentgenologic or clinical evidences of malignant disease.

L. W. PAUL, M.D.

Roentgen Picture of Silicosis in Different Industries. Torsten Bruce and Gunnar Jönsson. Acta radiol. 24: 89–112, April 30, 1943. (In English.)

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The Musculoskeletal System

The Spinal Cord

Gynecology and Obstetrics

The Genito-Urinary System

Contrast Media

ROENTGEN THERAPY

RADIATION EFFECTS

THE HEAD AND NECK

Radiographic Visualization of an Intracerebral Dermoid Cyst. Sidney W. Gross. J. Neurosurg. 2: 72-75, January 1945.

A case of intracerebral dermoid cyst is reported, unique only in that a plain x-ray film, before air injection, showed the lesion, which appeared as a large, regular, ovoid area of decreased density in the left frontal lobe. The patient had no focal signs or symptoms at any time. Roentgenograms are reproduced.

Healing Phenomena in the Sella Turcica after Treatment of Intrasellar Tumors. Olov Fr. Holm. Acta radiol. 24: 495-510, Dec. 31, 1943. (In German.)

The pituitary body occupies only 50 to 70 per cent of the sella, the remainder of the space being filled with connective tissue. This implies that the size of the pituitary does not necessarily vary with that of the sella, and tumor may be present without enlargement or *vice versa*. The typical picture of tumor is a balloon-like expansion, but this cannot be absolutely relied upon.

Of about 200 cases of tumor (all explored but 2), 27 having serial roentgen study are analyzed to determine the characteristics of the healing phenomena. Of the 17 patients who have been free of recurrence, all but 2 had enucleation of the tumor, followed, with a single exception, by roentgen therapy. The other 2 had only exploration, followed by roentgen therapy. Of the 17, 9 showed no change in the roentgenograms following treatment. Decrease in sellar size was seen twice, increase 4 times, and the appearance of intrasellar calcification twice. In the 10 cases showing recurrence there was also progression of the roentgen signs. Although the series is small, the author feels it shows the value of more careful roentgenologic control in determining the progress of the lesion.

LEWIS G. JACOBS, M.D.

Sideropenic Dysphagia or Cancer of the Hypopharynx? Bengt S. Holmgren. Acta radiol. 24: 455-461, Dec. 31, 1943. (In English.)

Iron deficiency is a fairly common condition, affecting women more often than men, and leads to a number of symptoms. Hypochromic anemia, low serum iron values, achylia or hypochylia, and various epithelial abnormalities are the most common. The dysphagia sometimes seen in this condition (Plummer-Vinson's syndrome) assumed special interest at Radiumhemmet (Stockholm) when it was noted that its symptoms were often found in female patients with cancer of the mouth or throat, and the possibility that the syndrome might predispose to cancer came into consideration. The typical roentgen picture is of one or several thin transverse bands constricting the esophagus, and in one case the author observed at autopsy a typical cancer at the site of the supposed sideropenic constriction. Two other patients, however, showed a similar constriction but no evidence of cancer over several years of observation. No case is made out for the predisposing effect of this condition to cancer, but at times the roentgenologic picture may make the diagnosis confusing.

LEWIS G. JACOBS, M.D.

Value of Contrast Filling of the Esophagus in X-Ray Examination for Goiter. Nils Frostberg. Acta radiol. 24: 113-120, April 30, 1943. (In German.)

Frostberg recommends contrast filling of the esophagus in all cases of goiter. In a great number of cases, a pressure effect of the goiter on the esophagus can be demonstrated, and valuable information can be obtained regarding circular goiter forms or aberrant goiter branches between the trachea and esophagus.

E. A. SCHMIDT, M.D.

THE CHEST

On the Division of the Lung Segments (III). W. J. Pothoven and Eelco Huizinga. Acta radiol. 24: 226-234, June 15, 1943. (In English.)

The present study deals with the division, into segments, of the right middle and lower lobes of the lung. [The other lobes were dealt with in previous publications. See Behr and Huizinga: Acta radiol. 19: 399, 1938, abst. in Radiology 32: 635, 1939, and Huizinga and Behr: Acta radiol. 21: 314, 1940, abst. in Radiology 36: 638, 1941.] The segmentation of the lung depends on the anatomy of the bronchial tree and is highly important for systematic bronchoscopic examination.

In the right middle lobe, the anatomical conditions are very constant: the bronchus proceeds ventrally and soon divides into a medial and a lateral branch. The architecture of the right lower lobe is much more complicated and shows numerous anatomical variations. The first constant large branch is the 1st dorsal bronchus; next follows the cardiac bronchus, which, however, may be absent. The next separate branch is a ventral branch, though it, too, may be absent. Finally, a ramification into a medio-dorsal and a ventro-lateral branch is observed. Consequently, five segments result in the right lower lobe, compared with two segments in the middle lobe.

In all, the authors differentiate ten segments in the right lung: three segments (apical, pectoral, and axillary) in the upper lobe; two segments (medial and lateral) in the middle lobe; five segments (upper dorsal, cardiac, upper ventral, lower dorsal, and lower ventral) in the lower lobe.

Considering the frequent difficulties encountered in complete visualization of the right bronchial tree, the authors' explicit directions for the bronchoscopist, based on these studies, are reprinted in full:

"The systematical bronchoscopy (in recumbent position) must, on the right side, be performed as follows. After determination of the bifurcation, the tube is inserted into the main right bronchus. The upper lobe bronchus soon goes off laterally, the orifice can be found by moving the head far to the left (Brünings, Jackson). The further ramifications cannot be seen. The head is replaced to its original position, the tube is moved on some centimetres further, by which the ramifications of the lower lobe bronchus can be seen in the depth. The next branch is the middle lobe bronchus, which goes off plainly ventrally, the mouth can be seen by displacing the head far downward. At a somewhat lower level the large first dorsal bronchus of the lower lobe follows. Now the head must be brought upward Then it is returned to its usua

tion, after which the tube is inserted into the lower lobe bronchus. Now the cardia bronchus follows, which goes off medially and can easily be failed by bronchoscopy. The orifice can be found by turning the head to the right. After 1–2 cm. the first ventral bronchus of the lower lobe is seen which must be inserted in the same way as the middle lobe bronchus. Finally the inspection of the medio-dorsal and latero-ventral ramification of the lower lobe bronchus is made."

E. A. SCHMIDT, M.D.

Segmental Extension of Pulmonary Abnormalities. Eelco Huizinga. Acta radiol. **24**: 295–305, Aug. 31, 1943. (In German.)

In earlier publications the author has described a division of the lungs into segments according to anatomical and physiological evidence (see preceding abstract). This is of importance in disease, since it leads to a more precise localization of the cause of a collapse. While normally blockage of a minor bronchus will not lead to atelectasis, such an event may readily occur in the presence of inflammation. By a study of the collapsed area the minor bronchus in which the disease is located may be identified, and the finding confirmed by bronchoscopy.

A number of illustrative cases and pathological specimens are shown to demonstrate this type of collapse and similar segmental spreads in tuberculosis.

LEWIS G. JACOBS, M.D.

Some Remarks on the X-Ray Appearance and Prognosis of Infant Tuberculosis. Torfinn Denstad. Acta paediat. **29**: 303–338, 1942. (In English.)

A study was made of 120 tuberculin-positive children (64 boys and 56 girls) in a Norwegian children's home over a ten-year period. The children averaged 1 year and 7 months in age; 38 were under a year, 84 (70 per cent) under 2 years. They were x-rayed immediately after admission to the home and generally checked several times during their stay, which in some instances was as long as five years, but, on an average a year and four months.

In the overwhelming majority of cases of tuberculosis in infants and children, x-ray examination reveals changes in the lungs. Paratracheal and hilar adenitis, which appear early and may be the only signs of primary pulmonary infection demonstrable roentgenologically, are the most common findings. In most instances, opacities of the lung are also found, ranging from minute, hardly visible to diffusely saturated lobular lesions. Probably, in most cases these represent the primary focus with its perifocal reaction. The saturated lobar opacities, so-called epituberculosis, at times are of an expansive nature; at others, atelectatic, as demonstrated by two cases in this series. The difference in the x-ray appearance, however, does not enable one to draw any conclusion with regard to prognosis. The opacities nearly all recede within six to eighteen months. In two cases in which death occurred from caseous tuberculous pneumonia, saturated lobar opacities were found with the same atelectatic appearance as in one of the cases of benign epituberculosis. Small, round, clear areas resembling cavities are not of prognostic significance, as they are not infrequently seen when benign opacities start clearing.

The author concludes that there is little reason "to maintain epituberculosis as a distinct picture of disease." Probably, the substratum for these lobar opacities is the same as for the less extensive benign opacities, *viz.* a perifocal reaction, at times complicated by atelectasis.

In some cases diffuse opacities with a mild course, often producing no symptoms, appear at a later stage of the illness. These opacities are more transient, sometimes with the appearance of pure collapse, at others more saturated, without any atelectatic character. Such opacities have appeared in conjunction with acute infectious diseases (measles, whooping cough); on the other hand, most of the children underwent such intercurrent infections without any roentgen evidence of exacerbation.

The prognosis in infant tuberculosis is relatively favorable. The direct mortality rate in this series, was 6 per cent, or 7 per cent computing the rate on those cases in which x-ray examination revealed pathological conditions in the lung. Five children died of meningitis, 2 of them with a miliary spread in the lung; 2 of caseous tuberculous pneumonia. Of 18 patients in the lowest age group, from birth to six months, only 2 died. The author adds a warning that "meningitis may shatter all expectations" after the tuberculous process in the lungs has apparently come to rest.

Bronchiectasis Following Atypical Pneumonia. Earle B. Kay. Arch. Int. Med. **75**: 89–104, February 1945.

During the past year 45 patients were treated for bronchiectasis at one Army hospital. The symptoms in 20 of these patients followed attacks of atypical pneumonia occurring during the winter of 1942–43. The diagnosis of atypical pneumonia was made elsewhere at the time of the original illness, and was confirmed by careful re-examination of the clinical records and roentgenograms at the hospital where the present study was conducted. In order to determine the permanency and extent of the bronchial and bronchiolar damage in these 20 cases, bronchography was repeated over a period of two to six months. In only 3 instances did the involved bronchi resume their normal contour and show evidence of clearing. In the remaining 17 patients the bronchiectasis appeared to be permanent.

Prior to the pneumonia these patients had no symptoms relative to the pulmonary system. The roentgenograms made at the time of induction into the Army were re-examined and found to be entirely within normal limits. The attacks of atypical pneumonia were characteristic in every respect except that they failed to show spontaneous healing in the usual period. After the acute episode had subsided, a cough remained, which became increasingly productive. Basilar râles persisted in the affected lungs. Serial roentgenograms showed an unresolved pneumonia.

Ten of the 17 patients with bronchiectasis had lobectomies, and in these cases pathologic verification of irreparable damage to the bronchial tree was obtained. The interval between the acute episode of atypical pneumonia and the operation varied from six to thirteen months. Representative case histories of 7 patients are presented. There are reported, also, 2 cases in which atypical pneumonia was followed by less severe bronchial changes—cases which the author believes might be regarded as intermediate stages in the development of bronchiectasis.

Spontaneous Mediastinal Emphysema with Pneumothorax Simulating Organic Heart Disease. Henry Miller. Am. J. M. Sc. 209: 211–220, February 1945.

Four cases of spontaneous mediastinal emphysema associated with a left pneumothorax are described. The history and physical and electrocardiographic findings simulated those of organic heart disease.

Macklin (Canad. M. A. J. 36: 414, 1937; Arch. Int. Med. 64: 913, 1939; J. Michigan M. Soc. 39: 756, 963, 1940) showed the probable mechanism of spontaneous mediastinal emphysema by demonstrating that air enters the perivascular sheaths of the pulmonary vessels, presumably through ruptures in the alveolar walls. This air eventually breaks through into the mediastinum. By the formation of large blebs along the vessels, the pulmonary circulation may be impeded. The air may extend from the perivascular sheaths into the connective tissues and dissect a path toward the pleura, where a subpleural bleb may be formed. While a pneumothorax could be produced by rupture of an emphysematous subpleural bleb, Macklin more commonly found a rent in the mediastinal wall which allowed access of air to the pleural cavity. From the mediastinum the air will follow the fascial planes into the neck, chest wall, about the pericardium, or retroperitoneally.

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Roentgenologic Appearance and Pathology of Intrapulmonary Lymphatic Spread of Metastatic Cancer. H. Peter Mueller and Ronald C. Sniffen. Am. J. Roentgenol. 53: 109–123, February 1945.

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In general, this diffuse infiltrative type of metastasis occurs in younger persons, the majority of cases being seen between the ages of thirty and forty-nine. The important clinical findings are dyspnea, cyanosis, a productive cough, and rapid cachexia. The roentgen manifestations appear to be due to masses of tumor cells within dilated lymphatics around bronchi and blood vessels. In differential diagnosis, miliary tuberculosis, pulmonary congestion and edema, pneumoconiosis, sarcoid, primary fibrosis with emphysema, and atypical pneumonia must be considered. In the individual case a definite diagnosis may be difficult unless there are other roentgenologic or clinical evidences of malignant disease.

L. W. PAUL, M.D.

Roentgen Picture of Silicosis in Different Industries. Torsten Bruce and Gunnar Jönsson. Acta radiol. 24: 89–112, April 30, 1943. (In English.)

The x-ray appearance of silicosis varies considerably according to the occupation of the patient. The

special x-ray features of each occupation are mainly concerned with (1) the prominence of linear markings (striation) compared with the mottling; (2) shape, delineation, size, and distribution of the discrete nodules; (3) situation of the massive lesions and the emphysematous areas.

Extensive linear consolidations and diffusely outlined, irregular nodular shadows were seen in porcelain workers, quartz mill workers, and workers in silicon alloys. Less pronounced linear markings with more rounded, denser, and more sharply outlined nodular shadows were observed in sandstone grinders, furnace masons, steel cleaners, and molders, while the roentgenograms of iron ore drillers were characterized by round, distinctly outlined shadows of considerable radiopacity. The discrepancy between these observations and those of other investigators is discussed.

With regard to the size of the nodules, no uniformity exists among the different occupations. In iron ore drillers the nodules are almost all of identical size. Molders, masons, and drillers in quartz mines show the largest nodules in the middle fields and infraclavicularly. As far as the location of the nodules is concerned, they are more prominently seen in the infraclavicular regions and middle fields though, generally speaking, no part of the lung is entirely free of mottling. In steel foundry workers and furnace masons the nodules show a tendency to accumulate in the apical areas and the lateral portions of the middle fields; a more even and general distribution of the mottling over both lungs is the rule in iron mine drillers. In quartz mine and iron ore drillers the nodules usually attain the size of a pea before coalescing to form massive conglomerations. So-called "egg-shell" consolidations in the hilar lymph nodes are seen chiefly in sandstone workers but are also occasionally present in second-stage silicosis of molders and steel cleaners. According to some observers, this "egg-shell" appearance is caused by infiltration of calcium underneath the capsule in the lymph node. Bronchographically, the deposits can be shown to lie outside the bronchi.

The location of the massive lesions and the deformation and emphysematous changes caused by contraction of the lung give the picture its typical appearance in the far-advanced stages of silicosis. The consolidations coalesce where the mottling is greatest; massive lesions, therefore, are generally situated infraclavicularly or in the upper parts of the middle fields, perhaps slightly higher in foundry molders and steel cleaners than in porcelain workers and quartz millers. In quartz mine drillers the massive lesions are situated in the lower parts of the middle fields or even basally. In iron mine drillers, the confluent areas have no definite site of predilection. In advanced silicosis, the lateral view is highly useful for the localization of the massive lesions. Situation of the conglomerates posterior to the hilus is such a constant feature in the silicosis of porcelain workers, quartz millers, foundry molders, steel cleaners, and furnace masons that location of lesions anterior to the hilus in these occupations raises the suspicion of non-silicotic etiology.

Emphysema may be expected to develop anywhere in the air-carrying pulmonary tissue but, since the massive lesions generally lie dorsally and above the hilar regions, the emphysematous areas show a predilection for the ventral and basal sections of the lung. Lateral views are necessary to demonstrate the borderline between consolidated and emphysematous areas. This line of demarcation shows a different course in different occupations. In porcelain workers and quartz millers, it runs diagonally from the jugular fossa through the hilus posteriorly and inferiorly toward the dorsal thoracic wall. In steel cleaners the lateral picture is dominated by the emphysema; the massive lesions occupy a smaller area superodorsally, which is separated from the emphysema by a semicircular line. In foundry molders and furnace masons, the lateral roentgenogram shows the consolidated region like an island surrounded on all sides by air-carrying emphysematous tissue. In the third-stage silicosis of iron mine drillers, where the centers of contraction have no sites of predilection, no characteristic borderline is visible between consolidated and emphysematous areas.

E. A. SCHMIDT, M.D.

Bronchographic Studies in Advanced Silicosis. Torsten Bruce and Gunnar Jönsson. Acta radiol. 24: 206–216, June 15, 1943. (In English.)

By means of bronchography, the authors studied the displacement of the bronchi caused by advanced silicosis. Five patients (2 steel workers, a quartz miller, a porcelain worker, and an iron ore driller) were examined, 4 of whom presented the typical silicotic distribution radiating from the hili and resulting in a similar pattern of displacement, while the fifth patient (the iron ore driller) showed basal lesions and a correspondingly different type of bronchial displacement.

The degree and direction of the bronchial displacement are directly dependent on processes of contraction. In the first 4 cases the center of contraction lay behind, above, and lateral to the hilus, and the ventral branches of the right eparterial bronchus and of the first left hyparterial bronchus were displaced upward and backward. The change of the peripheral bronchi was less marked, and the contraction exerted only a slight effect on the position of the dorsal bronchi. In the fifth case, where the center of contraction was located in the base of the lung, especially on the right side, there was considerable downward displacement of the eparterial bronchus combined with rather poor lipiodol filling of the other ventral bronchi. The dorsal bronchi were not displaced and were of "ordinary appearance."

E. A. SCHMIDT, M.D.

Toxic Properties of Silica. I. Bronchoconstrictor Effect of Colloidal Silica in Isolated Perfused Guinea Pig Lungs. Giles F. Filley, John G. Hawley, and George W. Wright. J. Indust. Hyg. & Toxicol. 27: 37–46, February 1945.

While this paper does not concern the roentgen aspects of silicosis, it is briefly noted here for the sake of calling it to the attention of those who are interested in the mechanism of the respiratory disability sometimes observed in silicotics. This, as the authors point out, may be of greater severity than would be expected from the x-ray findings.

Colloidal silica was found to produce a specific pharmacologic bronchoconstriction in isolated perfused guinea-pig lungs, apparently due to constriction of the smooth muscle fibers, but silica in soluble form was without such effect. Particulate silica produced mechanical obstruction in the tracheobronchial tree which obscured any possible pharmacological action, and this made impossible any definite conclusions as to its role in bronchospasm in human silicosis.

Occupational Illnesses in Cotton Industries. II. Chronic Respiratory Problems. Wayne L. Ritter and Morris A. Nussbaum. J. Indust. Hyg. & Toxicol. 27: 47–51, February 1945.

A cross-sectional survey was made of employees exposed to Upland cotton in Mississippi. Here, it has been the policy of the cotton industry over a number of years either to shift employees with "asthma" to some other job or to discharge them from work entirely. (The term asthma is applied loosely to any chest condition from chronic bronchitis, through pleurisy, to dyspnea.) Most employees with complaints of asthma are thus weeded out of the cotton industry. After a considerable search, 12 were eventually located. All were Negro males, ranging in age from thirty-seven to seventy, and all were or had been employed in cotton seed mills, either in the linter rooms or in the large seed storage bins. To make certain that the asthma could be precipitated by exposure to cotton dust, 2 of the men were taken into a lint room; both suffered asthmatic seizures. Physical examinations of this group of asthmatics showed no barrel-shaped chests, loss of chest expansion, or other abnormalities. Roentgenograms revealed no evidence of bronchiectasis, emphysema, fibrosis, or indeed any suspicious or undiagnosed pattern.

In Great Britain the Byssinosis Act of 1940 officially recognizes the possibility of permanent disability after prolonged exposure to cotton dusts and provides compensation to employees thus disabled following at least twenty years work in cotton mills. In Mississippi, only 26 people could be found who had done such work for this length of time; 14 of these had worked in excess of thirty years, one of them for forty-seven years. None of these men felt that their employment had in any way affected their health. Physical examinations and chest films revealed no pulmonary changes in this group.

Inquiries into the occupation of all persons on whom a diagnosis of bronchiectasis or emphysema had been made at the State Tuberculosis Sanatorium failed to show a single instance of employment in any of the dusty operations of the cotton industry.

No evidence was found in these studies to clarify or even support the existence of byssinosis as a clinical entity among employees exposed to Upland cotton. It was concluded that allergic individuals may develop a hypersensitivity to the high concentrations of cotton dust associated with some of the manufacturing processes in the cotton industry. There is apparently a wide variation in the severity of asthmatic episodes that result from this exposure.

Four Primarily Radiological Lesions Found in Traumatic Chest Cases: Preliminary Report. C. J. Hodson. Brit. J. Radiol. 17: 296–299, October 1944.

In a series of 250 chest casualties, four lesions were not infrequently demonstrated which have not previously been described:

1. Solid missile tracks were seen in 12 cases. When a missile traverses a lung it may leave a track demonstrable radiologically as a linear shadow. At first, this may be barely visible, but with subsequent bleeding and fibrosis it becomes increasingly apparent, and after two or three weeks may be seen as a clear-cut shadow 1.0 to 1.5 cm. in width. This track may direct the observer to a bullet otherwise invisible. As healing proceeds, the track becomes narrower. It may remain as a fine line or disappear.

2. Air-containing missile tracks are due presumably to the draining of the contents of a solid track by a bronchus. Six such cases were observed, all associated with bone damage at one end and a foreign body and exit wound at the other. The tracks varied from 4 to 10 cm. in width. Viewed end-on, they appear round or oval and may resemble cavities. They heal slowly and may leave a linear streak.

3. Extrapleural hematomata were observed in association with rib fractures and foreign bodies coming to rest beneath the pleura. They appeared as rounded to fusiform densities on the chest wall and resolved slowly. Unlike pleural effusions, they do not spread along the chest wall.

4. Lung "contusion" is a name applied tentatively to a diffuse shadow seen in many injuries, clearly not due to pleural effusion. It may occur in any type of trauma, but is observed particularly in contusions and blast injuries and in tangential wounds. The pathology has not been determined. Hemoptysis may be present.

SYDNEY J. HAWLEY, M.D.

Radiographic Changes in the Lungs After Strangulation. R. V. Lee and H. W. Jamison. Air Surgeon's Bull. (No. 7) 1: 14, July 1944.

A 21-year-old man was caught in a crashed airplane in such a way that his neck was constricted, shutting off the trachea completely. Immediately after the accident he was conscious and beating the ground frantically. In the seven to twelve minutes which passed before his release the patient became profoundly cyanotic and lapsed into unconsciousness. When removed from the wreckage he showed no signs of life for four or five minutes, was flaccid and apneic, with pupils dilated and no perceptible pulse. Artificial respiration and other measures were instituted and after twelve hours the patient was apparently normal.

Roentgenograms of the chest were taken at approximately three hours, fifteen hours, and thirty-seven hours after the accident. The first film revealed diffuse, mottled infiltration throughout both lungs, accentuated in the parahilar regions and fading toward the periphery and lung bases, resembling acute, intensive passive congestion and edema such as are seen following acute coronary occlusion. The heart appeared moderately dilated. Fifteen hours after the accident most of the extensive mottling had cleared, leaving only thickened hilar and bronchovascular trunk markings with hazy peribronchial residual edema. The heart measured 8 mm. less in transverse diameter than on the original film. Thirty-seven hours following the accident the patient was ambulatory, the lungs were entirely clear, and the heart was normal in size and shape. The roentgenograms are reproduced.

Pulmonary Changes in Cardiospasm. Lloyd E Hawes and Arthur B. Soule, Jr. Am. J. Roentgenol. 53: 124–128, February 1945.

Two cases of cardiospasm are reported in which there were extensive roentgen changes in the lungs without significant pulmonary signs or symptoms. In one patient with a long history of cardiospasm there was an increasing interstitial pulmonary fibrosis. The second patient showed an area of increased density in the right upper lobe which persisted without change over a period of three years. It was thought to represent an area of

fibrosis which developed from inhalation pneumonitis. Four types of pulmonary complications associated with cardiospasm have previously been reported: basal pneumonitis, lung abscess, bronchiectasis, and pleural effusion. In these cases there have been pulmonary symptoms in addition to those due to the cardiospasm. The cause of these various lesions seems to be the inhalation of fluid from the reservoir in the esophagus, during spasms of coughing or while the patient is asleep.

L. W. PAUL, M.D.

Celothelioma of the Epicardium: Report of Case. C. J. Hansson and N. Söderström. Acta radiol. 24: 183–189, June 15, 1943. (In English.)

The authors report a case of malignant tumor of the epicardium in a 51-year-old man who was admitted to the hospital with the preliminary diagnosis of "myocardial damage, possibly pericarditis." The x-ray examination showed only slight enlargement of the superior mediastinum. Electrocardiograms revealed a definitely pathologic condition, resembling the "T type" seen in coronary thrombosis. Venography, with the aid of perabrodil, revealed a bilateral block of the axillary vein at a point approximately on a level with the clavicle. While the downward extent of the obstruction into the superior vena cava could not be determined, the fact that the azygos vein showed contrast filling indicated that it did not reach farther down than to the point where the latter vein emptied into the vena cava. More detailed study was prevented by the patient's condition, which was characterized by increasing cyanosis and dyspnea.

Autopsy showed tumor involvement of the heart at the apex, on the anterior wall of the right ventricle, and in the posterior wall of the right auricle. The tumor infiltrated into the muscular tissue, the pericardium, the endocardium, and the intima of the pulmonary artery. The pathological diagnosis was malignant endothelioma.

The striking clinical features in this case were the absence of definite roentgen signs pointing to a mediastinal tumor and the marked electrocardiographic changes of the coronary type. At an early stage of the disease, the patient received radiation therapy, but the dosage was apparently too small to influence the tumor.

E. A. SCHMIDT, M.D.

Calcific Aortic Valve Stenosis: A Clinico-Pathologic Correlation of 22 Cases. Nathaniel E. Reich. Ann. Int. Med. 22: 234–251, February 1945.

Twenty-two consecutive cases of pure calcific aortic valve stenosis found at the autopsy table of Kings County Hospital (Brooklyn, N. Y.) from 1934 to 1942 have been reviewed. They were carefully selected on the basis of calcareous infiltration of the aortic valve leaflets only, in the absence of significant degrees of involvement of other valves. Cases with other valvular defects were avoided so that the effects of a pure aortic stenosis on the size and weight of the heart, symptomatology, physical findings, and electrocardiogram could be more clearly evaluated.

The diagnostic criteria include the history, characteristic pulse, palpable thrill over the base of the heart, loud rough systolic murmur at the base of the heart or entire precordium, heard loudest over the aortic valve, decreased intensity or absence of the second aortic sound, and cardiac hypertrophy. Visualization by fluoroscopy, occasional demonstration on the roentgenogram, and electrocardiographic changes are helpful laboratory aids. The cardinal symptoms are evidences of left ventricular failure, angina pectoris, dizziness, and syncope.

The roentgenographic and fluoroscopic diagnosis of calcium deposits in the valve leaflets by special technic has been amply described elsewhere (Sosman and Wosika: Am. J. Roentgenol. 30: 328, 1933). In 36.4 per cent of the present series, the diagnosis based on history and physical findings was confirmed by autopsy. The frequency of identification may be almost doubled (64 per cent) by the additional fluoroscopic demonstration of calcification of the aortic leaflets or annulus. Arteriosclerotic dilatation of the aorta may be differentiated by roentgenographic demonstration of the dilatation and calcific plaques in the aorta rather than calcification in the region of the valve.

Electrocardiographically, left axis deviation and T-wave negativity were helpful in differentiation of aortic insufficiency and mitral lesions, since these tend to produce hypertrophy in the right chambers as well, with resultant right ventricular strain.

Rheumatic fever and arteriosclerosis have a definitely established relationship to calcific aortic valve stenosis. The latter was three times as important etiologically in the author's series as the former. Subacute bacterial endocarditis would appear to be a rarer cause, the calcification occurring as part of the healing process after the patient has become bacteria-free.

Calcific aortic valve stenosis is characterized pathologically by a tendency to hyalinization of the connective tissue, depositions of lipoid material in the aortic valve ring and in the aortic valve, and subsequent calcification of the affected tissues. In the rheumatic type, calcification begins in the ventricular aspect of the distal third of the cusps; in the arteriosclerotic types it begins at the base of the aortic surface. The degree of calcification closely parallels the degree of stenosis.

The greatest number of cases in the series reported occurred in the age group 50 to 80 years. The ages ranged, however, from 25 to 82, with an average of 59. A rheumatic etiology, as would be expected, was more frequent among the younger patients. Males outnumbered females 4 to 1 in the rheumatic group; arteriosclerotic involvement was 7 times more frequent in males. The average age in the arteriosclerotic group was twenty-three years more than in the rheumatic group.

Following the onset of symptoms, the total duration of the illness ranged from three days to eight years. The course was generally slow and progressive, the valve becoming more and more stenosed as more calcium was deposited on the leaflets. The rheumatic group had a tendency to a longer period of hospitalization than the arteriosclerotics. Cardiovascular and extracardiovascular causes of death were about equally divided, but of the former, pulmonary edema and congestive heart failure predominated. Sudden death may be caused by myocardial infarction due to acute coronary occlusion or coronary insufficiency, severe cerebral ischemia, cardiac standstill, ventricular fibrillation, hypersensitive carotid sinus reflex, or obstructing thrombi formed on the stenosed aortic valve.

The author concludes as follows: "In the absence of hypertension and definite mitral valve involvement,

a systolic murmur at the aortic area should suggest calcific aortic valve stenosis. This possibility becomes greater in the presence of dizziness, precordial pain, regular sinus rhythm, cardiac enlargement, and an absent second aortic sound. Roentgenologic and especially fluoroscopic studies, as well as electrocardiographic findings, may verify this."

STEPHEN N. TAGER, M.D.

Clinical and Theoretical Considerations of Involvement of the Left Side of the Heart with Echinococcal Cysts. A Review of the Literature, with a Report of Five Cases, Including One Observed by the Authors. John H. Peters, Lewis Dexter, and Soma Weiss. Am. Heart J. **29**: 143–167, February 1945.

The authors analyzed 56 reported cases of hydatid cysts of the left heart, together with 5 new cases and one additional case which was under their observation during its terminal phase, giving the pathogenesis, clinical diagnosis, prognosis, and treatment. They are chiefly concerned with the rare cases in which the primary infection passed through the hepatic and pulmonary filters to involve the heart and, secondarily, the peripheral organs. Echinococcosis is predominantly a hepatic and pulmonary disease. Some doubt exists regarding the mode of transmission from animals to man. It is assumed to be by way of the digestive tract. Larvae leave the digestive tract, enter the portal circulation, and most of them are filtered out by the liver, where an unknown and variable number survive to form cysts. A small number of the larvae pass through the liver and enter the heart and pulmonary circulation. About one-third of them are retained in the capillary bed, and the remainder pass into the systemic circulation. A small percentage of the primary cysts are formed in the heart, the larvae having entered by way of the coronaries, mainly the right.

A certain proportion of the encysted larvae die, and unless the cysts cause mechanical difficulties, they become fibrosed, with or without calcification, and are discovered only by accident at operation or autopsy. Living cysts grow at a fairly constant rate; a certain proportion rupture, and spread of the disease frequently follows. Multiple cysts may develop in the tissues adjacent to the site of rupture. Distant spread of the disease follows rupture into the peritoneal cavity, large blood vessels, biliary passages, respiratory or digestive tract, unless the infesting material is completely expelled in bile, feces, sputum, or vomitus.

There are 5 main types of cardiac cysts: (1) dead cysts, usually found at autopsy; (2) living intact cysts, which, if detected roentgenologically, should be extirpated to prevent further growth or subsequent rupture; (3) cysts which have ruptured into the pericardium, causing adhesions, with or without formation of secondary cardiac cysts; (4) pedicled cysts in the heart chambers, which may interfere with valvular function, and are found from time to time at autopsy; (5) cysts which have ruptured one or more times into the heart chambers, causing systemic disturbances.

Symptoms arise from the effect of primary cysts on the function of the myocardium, either as a result of myocardial destruction, interference with valvular function, or disturbance in conduction. When a cyst ruptures, systemic disturbances follow. There may be arterial occlusion by daughter cysts or other material. Germinal elements may be disseminated into the peripheral tissues and organs, where they may or may not survive and produce secondary cysts. There may be an allergic response on the part of the body to the protein substance liberated.

The diagnosis of cardiac echinococcosis is essentially the same as of infestation of other organs. Cardiac cysts tend, however, to be asymptomatic, and may be recognized only roentgenologically (if calcified). The presence of cysts in peripheral organs may serve as a clue and lead to roentgen detection of a cyst in the heart. Sudden unexplained anaphylactoid collapse in persons born in regions where the condition is endemic should arouse suspicion.

The article concludes with reports of 8 cases (2 previously reported) and a long bibliography.

HENRY K. TAYLOR, M.D.

THE GREAT VESSELS

Clinical and Pathological Findings in Aortic Atresia or Marked Hypoplasia of the Aorta at Its Base. Helen B. Taussig. Bull. Johns Hopkins Hosp. **76**: 75–82, February 1945.

Atresia or marked hypoplasia of the aorta at its base is a rare malformation incompatible with life for more than a few days. Two cases of this condition with remarkably similar clinical findings are reported. Both infants were cyanotic at birth and throughout their brief lives. Within the first few days both showed enormous cardiac enlargement and evidence of cardiac failure with marked engorgement of the liver and an extremely weak pulse. Fluoroscopy showed that the hypertrophy of the heart was primarily due to enlargement of the right auricle and right ventricle. In the anteroposterior view the heart appeared enlarged and the pulmonary conus markedly distended, indicating that the pulmonary artery was normally placed. Examination in the left anterior oblique position showed that the anterior margin of the cardiac shadow extended forward nearly to the anterior chest wall. This finding confirmed the impression that the right ventricle was huge. The posterior margin of the cardiac silhouette did not extend further back than normal, showing that the left ventricle was not enlarged. Films were not obtained in either case, due to the critical condition of the patients. Autopsies confirmed the clinical diagnosis of complete or functional atresia of the aortic orifice.

Aneurysms of the Abdominal Aorta. Joseph Epstein. Ann. Int. Med. **22**: 252–270, February 1945.

Aneurysm of the abdominal aorta must be considered in the differential diagnosis of obscure abdominal disorders. A general accord as to the age distribution of the two major groups of aneurysms is recognized, the syphilitic occurring in the fourth and fifth decades and the arteriosclerotic in the sixth and seventh. Other etiologic features than syphilis and arteriosclerosis are trauma, such as perforating gunshot or stab wounds of the abdomen, contiguous extra-arterial disease with secondary injury to the vascular wall, inflammatory vascular lesions such as tuberculosis, streptococcus infections, and rheumatic fever.

Aortitis is the most frequent lesion of tertiary syphilis and may be its sole manifestation. The saccular aneurysm characteristic of the disease is the result of an inflammatory process which begins as a mesarteritis. In arteriosclerotic aneurysms the arterial wall is

weakened throughout because of progressive medial changes. After the elastic fibers degenerate, they are replaced by fibrous hyaline tissue, a non-inflammatory process in which the change progresses from the intima to the adventitia. The increasing dilatation of the vessel which ensues reflects its inability to resist intravascular tension.

The pressure of the enlarging aneurysm produces a chronic inflammatory reaction in the cancellous bone, with consequent erosion of the vertebrae and sometimes of the lowermost ribs. The cartilage, being avascular, does not show this reaction and consequently is preserved. The twelfth thoracic and first two lumbar vertebrae are the most frequent sites of erosion. The left anterior aspect is the earliest site of resorption, a phenomenon explained by the position of the aorta at these levels. Subsequent resorption of bone results in the exertion of pressure on nerve roots and in extreme cases on the spinal cord, causing paraplegia.

Roentgenologically the aneurysm may indicate its presence by the diverse changes the expanding lesion produces on contiguous organs and skeletal structures. The protrusion of an aneurysmal sac ventrally and to the left predicates that the best evidence of bone resorption will be seen in lateral and lateral oblique projections. *The intervertebral disks are never destroyed.* Vertebral erosion in the presence of the senile arteriosclerotic aneurysm was not observed in any of the author's 9 cases. The diaphragm may be elevated, thereby changing the cardiophrenic angles. The stomach may be indented, or the kidney and ureters displaced. Direct roentgen examination of the abdomen may reveal the arteriosclerotic wall of an aneurysm as a thin curved line of calcification lateral and anterior to the vertebral column.

As a result of rupture followed by retroperitoneal and intraperitoneal hemorrhage, a number of distorting phenomena of the viscera may occur. Rupture may occur into the pleural cavity, the mediastinum, or the gastro-intestinal tract. Intestinal obstruction, both mechanical and paralytic, has been produced by this mechanism. Portal, splenic, and mesenteric vein thrombosis have been reported. Rupture of the aneurysmal sac may result in sudden death.

Aneurysms of the abdominal aorta are notorious for the latency of their clinical expression. Pain, of varying nature and intensity, is the predominating symptom. It may be caused by hemorrhage into the perirenal space, by vertebral erosion, by pressure on the dorsal nerve roots, or by displacement of the kidney and ureter with obstruction.

The cardinal physical finding is an abdominal mass, usually in the epigastrium, and characteristically transmitting an expansile pulsation. The differentiation from a mass of cancerous retroperitoneal lymph nodes may be difficult because not only may the latter mass pulsate, but it may be associated with vertebral erosion. The intervertebral disks, however, are destroyed in neoplastic disease and the vertebrae involved present an irregular, patchy, ragged outline with a worm-eaten appearance, not characteristic of erosion due to aneurysm. Other pathologic entities which may be simulated by abdominal aortic aneurysms include retroperitoneal sarcomata, gumma of the liver, and omental tumors.

Since the kidney and ureter are often displaced by an aneurysm, as has been evidenced by many postmortem examinations, the radiologist must employ urography in the investigation of abdominal aortic lesions. Such displacement was observed in 2 of the author's cases.

The correct diagnosis was made in 4 of the 9 cases reported here. The symptoms were mostly those suggestive of renal disease, resulting in the diagnosis of renal calculus, pyelonephritis, and perinephric abscess. Gastro-intestinal cancer was considered in 2 cases, an appendiceal abscess in one, and a perforated viscus in another.

In two patients the diagnosis of calcified aortic abdominal aneurysm was made as an incidental observation. In these cases there were few or no symptoms or physical findings to direct attention to the aneurysm, and the roentgenograms alone established the diagnosis.

Roentgenographic examination was the most fruitful of the laboratory procedures. Calcification in the dilated vascular wall was present in 6 patients and was the most frequent finding. The serologic reaction was positive in two cases, and in both of these autopsy revealed the presence of vascular syphilis.

The cases of aortic abdominal aneurysm presented focus attention on the importance of painstaking roentgen examination in the diagnosis of this obscure malady. The most recent contribution has been made by intravenous urography. The importance of identification of vascular calcification must be stressed, because even a thin, small deposit may, by its location, lead to a proper diagnosis. Pneumoperitoneum was helpful in one case. STEPHEN N. TAGER, M.D.

Diagnosis of Aneurysms of the Abdominal Aorta. Aguinaldo Lins and Fernando de Morais. Rev. clin. de São Paulo **16**: 79–84, 1944.

After a short historical introduction, the authors call attention to the relatively high frequency of abdominal aneurysms among local workers in Recife, Brazil, and conclude that it is possible to make the diagnosis in most cases without resorting to the complex technic of aortographic examination. Symptomatology, with special reference to pain, is discussed. Forward displacement of the stomach is noted. Calcification is evaluated. While erosions of the vertebral bodies are not uncommon, kyphosis is never found. Some prefer the use of pneumoperitoneum or visualization of the digestive tract by use of barium or air. Illustrative examples of the condition as shown in roentgenograms are given, and various aneurysmal, arterial, and cardiac tracings are presented. SEBASTIO V. FRANCO, M.D.

Arteriographic Findings in Thrombosis of the Internal Carotid. S. Erikson. Acta radiol. **24**: 392–402, Oct. 31, 1943. (In German.)

Nine cases of thrombosis of the internal carotid artery are presented, 6 in males and 3 in females. Roentgenograms from some of these are reproduced.
F. ELLINGER, M.D.

THE DIGESTIVE SYSTEM

Roentgenography of Small Zenker's Diverticula (Pulsion Diverticula) During Various Phases of Swallowing. Bengt S. Holmgren. Acta radiol. **25**: 40–55, Feb. 29, 1944. (In German.)

After discussion of the various theories of the origin and development of pulsion diverticula of the esophagus

the author describes 8 cases observed in 6 female and 2 male patients between 63 and 75 years of age. It was found that, during the act of swallowing, the diverticulum disappears as the contrast medium passes the inferior part of the hypopharynx and reappears as soon as the medium has passed the upper orifice of the esophagus. This phenomenon is not observed in larger forms of Zenker's diverticulum. Excellent illustrations are included. F. ELLINGER, M.D.

Contribution to the Roentgen Examination of the Stomach. Y. Scuderling. Acta radiol. 24: 384–391, Oct. 31, 1943. (In German.)

The author reports 2 cases of snail-like contraction of the lesser curvature of the stomach in male patients 33 and 38 years of age. The condition occurs as a rule following chronic ulcer. In one of the patients the ulcer was no longer demonstrable. In the other it persisted and the stomach was of the hourglass form. In each instance, the organ showed roentgenographically a "tobacco-pouch" appearance. Symptoms had been present five and eleven years, respectively, but were not striking. F. ELLINGER, M.D.

An Accessory for Radiographic Examination of the Stomach. Y. Scuderling. Acta radiol. 25: 56–58, Feb. 29, 1944. (In German.)

To facilitate administration of the barium meal, the author uses a metal goblet containing a glass, attached to the cassette in such a way as always to remain in a vertical position. To make it easier for the patient to find the glass in the dark room, a label in fluorescent letters is provided. F. ELLINGER, M.D.

X-Ray Diagnosis of Benign Tumors of the Stomach. Gösta Forssman. Acta radiol. 24: 135–165, April 30, 1943. (In German.)

The author reports a series of 30 benign tumors of the stomach which he observed during a ten-year period. Simple polyps were most frequently encountered (11 cases), followed by myoma (8 cases), polyposis (6 cases), and papilloma (3 cases). There was one case each of neurinoma and cavernous hemangioma. The correlation of the x-ray appearance with the operative findings is discussed in detail; the mucosa in the tumor area especially was studied explicitly. Myomas present an evenly rounded surface; the mucous membrane is generally intact and movable; only occasionally are large craters seen. In papilloma, the surface presents the typical "papillomatous" appearance, while hemangiomas present soft indentations with accumulations of phleboliths in the cavernous spaces. Studies further included the movability of the tumors in relation to the mucous membrane and the muscular wall and the compressibility of soft tumors, as well as peristaltic phenomena and the appearance of relief outlines in the neighboring mucosa.

The difficulty of definite differential diagnosis is stressed in the case of benign tumors with a tendency to malignant proliferation, especially papillomas and simple polyps. In some cases with malignant change not even the gross examination during and following operation raised the question of malignancy, and the later microscopic diagnosis was a surprise to both surgeons and roentgenologists.

The treatment of choice is surgical removal. Generally, gastric resection is considered preferable to simple tumor extirpation, at least in the case of papillomas. E. A. SCHMIDT, M.D.

Leiomyosarcoma Ventriculi: Three Cases. Olav Holta. Acta radiol. 24: 166–173, April 30, 1943. (In English.)

Sarcomas of the stomach wall are relatively rare, accounting for only about 1 per cent of all gastric cancers. Three cases are reported by the author. Partial stomach resection was performed in all of these, and the diagnosis was established microscopically. In each instance roentgen examination had shown a sharply defined endogastric tumor of an appearance usually considered typical of a benign lesion. The clinical symptoms of leiomyosarcoma (dyspeptic discomfort, late vomiting and hemorrhage, pain immediately after meals or tardy "hunger pain") are not characteristic and point just as often to ulcer as to tumor invasion. According to Holta, x-ray examination cannot differentiate conclusively between sarcoma and other gastric neoplasms. Treatment is by radical surgery. If metastases are absent, the prognosis is relatively favorable following operation; freedom from symptoms for up to fourteen years has been reported. In the unoperated case, the average time of survival following onset of symptoms is three and a half years. E. A. SCHMIDT, M.D.

Volvulus of the Stomach. Nils Frostberg. Acta radiol. 24: 217–225, June 15, 1943. (In German.)

Volvulus of the stomach is rarely diagnosed before operation or autopsy. According to the extent of the volvulus, partial and complete types are differentiated. As far as the direction of the gastric rotation is concerned, the mesenterio-axial type (in which the stomach rotates about an axis formed by the lesser omentum and the body of the stomach) predominates over the organo-axial type (in which the stomach rotates on its longitudinal axis). With regard to etiology, five types have been described: (1) volvulus in diaphragmatic hernia, (2) volvulus in gastric ulcers, (3) volvulus in inflammatory processes, (4) volvulus in displacement of neighboring organs, and (5) idiopathic volvulus. In the differential diagnosis a number of other affections in the epigastrium must be considered, especially perforated ulcer, ileus, acute pancreatitis, and mesenteric embolus. In acute forms, stenosis of the cardia results, which prevents filling of the stomach by contrast medium. The treatment in acute cases is surgical; in chronic or partial cases without definite symptoms, no intervention is indicated.

The author describes a case of complete mesenterio-axial volvulus of the stomach in a 78-year-old woman. The diagnosis was made roentgenologically and confirmed by autopsy. At the same time, an adenocarcinoma of the stomach and marked ptosis of the spleen, combined with myeloid enlargement, were found, which factors probably contributed to the occurrence of the volvulus. E. A. SCHMIDT, M.D.

Case of Diverticulum in the Body of the Stomach. Herman Pedersen. Acta radiol. 24: 311–316, Aug. 31, 1943. (In English.)

After a discussion of the pathogenesis of gastric diverticula, the author reports one the size of the closed fist, arising from the anterior wall of the stomach in a 72-year-old woman who had been asymptomatic up to

two months before the x-ray study and had since presented an ulcer-like syndrome. Surgical removal produced symptomatic relief. The diverticulum contained all three layers of the gastric wall and, since cicatricial changes were found around its neck and in the adjacent pyloric walls and sac, it was believed to be a result of scarring from gastric ulcer.

LEWIS G. JACOBS, M.D.

Immersion Blast Injury—Clinical Experiences. E. Lyle Gage. U. S. Nav. M. Bull. 44: 225–231, February 1945.

Pathology of Immersion Blast Injury. Asher Yaguda. U. S. Nav. M. Bull. 44: 232–240, February 1945.

Ninety-eight men survived a sinking at sea and subsequent depth charge explosion, following which they were in the water for nineteen hours and on the rescue boat seventeen hours before being hospitalized. Fourteen were in critical condition and 5 others were seriously injured. Nearly all suffered to some extent from exposure, sunburn, conjunctivitis, and fatigue. There was no evidence of injury to the genito-urinary tract, central nervous system, or ear drums in any of the group. Several suffered minor fractures. A number had evidence of injury of the chest (a pneumothorax with fractured ribs in one instance). Twenty-three suffered serious intra-abdominal injury and, of these, 4 died within the first forty-two hours and a fifth five days later. X-ray examination was made in 12 of the remaining cases and evidence of air in the peritoneal cavity was found in 4. Of the 18 survivors, 14 experienced nausea and vomiting and 11 had diarrhea; 3 passed blood by rectum.

Since all of these patients were received thirty-six hours after injury, conservative treatment was decided upon, with morphine given freely and no food or enemas until it could be definitely determined whether or not an intra-abdominal injury was present. Plasma, dextrose, or saline was given as indicated. Suction with the Miller-Abbott or Wangensteen tube was used in 10 cases. The cause of death of the first four patients was generalized peritonitis, and of the fifth, plasma anaphylaxis.

Detailed reports of four cases are given illustrating the diversity of response to immersion blast perforation of the bowel. Three cases required surgical interference. In two of these, this consisted in drainage of abscess cavities.

Careful questioning showed that all those with severe intra-abdominal injury were either lying on the abdomen in the water or were in water above the abdomen and facing the blast, which was estimated to to be within one hundred feet of them.

The important point of this article is the fact that so many recovered with conservative management despite serious intra-abdominal injury and a delay of thirty-six hours before effective therapy could be started.

The paper by Yaguda includes reports of the fatal cases with autopsy findings. He concludes: "From the findings described, it is seen that the damage resulting from immersion blast concussion is suffered chiefly by those organs which are normally air-containing and which are submerged at the time of the detonation. The intestine, therefore, being the most often submerged air-containing organ, bears the brunt of the injury. The lungs suffer relatively less severe injury and probably, when a sufficient number of autopsies are available for statistical study, will be found to be the chief cause of death in only a smaller percentage of immersion blast casualties. It is probable that the total injury in both the lungs and the intestines determines, in the first few hours after injury, whether the patient will die shortly or is capable of recovery."

BERNARD S. KALAYJIAN, M.D.

Present Status of Chronic Regional or Cicatrizing Enteritis. H. L. Bockus. J. A. M. A. 127: 449–456, Feb. 24, 1945.

Inflammatory Lesions of the Small Intestine: Surgical Aspects. Henry W. Cave. J. A. M. A. 127: 456–458, Feb. 24, 1945.

In six and three-quarter pages of text, tables, and illustrations, Bockus has presented an extremely well ordered and thoughtful exposition on a subject which all too often has been confused rather than clarified in medical writings. The factual knowledge regarding chronic enteritis has been catalogued. The incidence and the clinical and roentgenologic manifestations are presented.

Controversial features of regional enteritis, related largely to probable etiological factors, are discussed at some length. It seems possible, if not probable, that the characteristic abnormalities of the gut wall which have been described in examples of this disease depend for their inception upon some situation which produces blockage of lymph drainage.

Results obtained by means of radical resection of affected segments of the intestinal tract in the case of 19 patients are used to illustrate the efficacy of surgical methods of treatment. In 37 per cent of the group good results were obtained. Operative mortality for this particular group of patients reached 16 per cent. Medical management is based to a large extent upon the maintenance of adequate nutrition in the face of severe derangement of the processes of digestion. Protein deficiency must be overcome. The newer drugs, penicillin and the sulfonamides, have not as yet been spectacular in their effects. Roentgen therapy does not look to be promising in the control of ileitis. Spontaneous remissions of symptoms are known to occur. This fact should encourage both patient and physician.

Cave's paper deals with regional ileitis as a surgical problem. Twenty-three patients with regional ileitis were treated surgically by the author during a period of ten years. Whereas most surgeons recommend resection of visibly involved gut, together with a cuff of normal intestine, Garlock and his associates have reported highly gratifying results from ileocolostomy and exclusion of the diseased segment. Appendectomy, either early or late in the course of regional ileitis, "invites disaster."

FRED JENNER HODGES, M.D.
(University of Michigan)

Congenital Ileal Atresia with Gangrene, Perforation and Peritonitis in a Newborn Infant. Staged Operations: Obstructive Resection, Ileocolostomy and Excision of Exteriorized Ileum. Ernest E. Arnheim. Am. J. Dis. Child. 69: 108–116, February 1945.

Congenital atresia of the ileum is characterized by the usual signs and symptoms of intestinal obstruction: persistent vomiting of bile-stained fluid and

increasing abdominal distention. Roentgen examination reveals distended loops of small bowel and, later, fluid levels. A barium meal is not only unnecessary, since the newborn infant swallows sufficient air to distend the bowel proximal to the obstruction, but may be dangerous because of possible aspiration of the vomitus.

The case described represents the twelfth cure reported in the literature and the second to be obtained after gangrene, perforation, and peritonitis had supervened. The patient was a female infant aged 26 hours. The operation devised by the author was performed in 3 stages under ether anesthesia. The first stage consisted of resection of the necrotic portion of the ileum proximal to the site of atresia and exteriorization of the proximal and distal loops of ileum. Sixty hours after the resection, a side-to-side, isoperistaltic ileo-transverse colostomy was accomplished. At this time both loops of the exteriorized ileum were opened by removing the silk sutures at the cut ends. Bronchiolitis developed on the 18th postoperative day but responded to oxygen and sulfathiazole therapy after one week. On the 44th postoperative day, a severe diarrhea began, continuing for four days. This responded to a transfusion of citrated blood and fluids given parenterally. The third stage, to remove the exteriorized ileum, was performed fourteen months after the second operation. On re-opening the abdomen, a second atresia was found in the course of the distal loop of ileum near the cecum. Follow-up examination at the age of 2 1/2 years showed the child to be apparently normal. Her weight was 29 pounds and height 36 inches. There was one normal stool a day, the abdomen was not distended, and the abdominal scars were firm.

The dietetic and general care of the patient, as well as the operative procedures, are described in minute detail. The article is well illustrated with sketches of the operation, photographs of the patient and operative specimens, and roentgen reproductions.

LESTER M. J. FREEDMAN, M.D.

Roentgenologic Diagnosis and Treatment of Intussusception in Children. Hans Hellmer. Acta radiol. 24: 235–258, June 15, 1943. (In English.)

The author reports 110 cases of intussusception in children diagnosed roentgenologically during a period of nine and a half years at the Lund University Clinics. In all cases a barium enema was employed not only as a means of diagnosis but also with the intent to reduce the invagination under fluoroscopic control. This attempt at reduction was successful in 80 per cent of the cases (88 cases). In 51 cases, 30 of which were reduced by means of barium enema, the intussusception had started in the small intestine. In 7 cases the intussusception began in the colon, while in almost one-half of the cases (52) the site of origin could not be definitely ascertained.

Hellmer answers the objections raised by Obst (Ergebn. d. Chir. u. Orthop. 30: 372, 1937) against attempts at non-operative reduction of intussusception. Unlike Obst, he thinks the method well applicable to cases of obstruction in the small intestine and does not consider the dangers (loss of time, obscuring of symptoms, etc.) important enough to prevent its use.

Narcosis was not necessary in any cases of roentgenologic diagnosis and reduction.

E. A. SCHMIDT, M.D.

Radiologic Picture of Acute Invagination of the Small Intestine in Children. Jens M. Nordentoft. Acta radiol. 24: 469–477, Dec. 31, 1943. (In French.)

Small intestine intussusception in children is uncommon, constituting 5 to 8 per cent of all cases of intussusception; if only children under a year or two are considered, the percentage is still lower—2 to 3 per cent. Since its clinical diagnosis is difficult and it cannot be demonstrated by barium enema, it is desirable to consider the value of radiologic examination in this condition. While it is evident that a barium enema will not demonstrate small bowel intussusception, a plain film will show the presence of a marked obstruction and, at least at times, permit demonstration of an invagination of the ileum. In some cases, also, reflux from an opaque enema will show this. Careful fluoroscopic study during injection of the enema and after evacuation, with special attention to the ileocecal region, is important, because of the frequency of intussusceptions in this region; reduction may be accomplished by the examination. Five cases are recorded. LEWIS G. JACOBS, M.D.

Value of the Barium Enema in the Diagnosis and Treatment of Intussusception in Children (Illustrated by About 500 Danish Cases). Jens M. Nordentoft. Acta radiol. 24: 484–488, Dec. 31, 1943. (In English.)

This is a summary of the material presented by the author in Supplementum LI to *Acta Radiologica*. His study includes 440 cases of intussusception in children, in 202 of which barium enema studies were done.

Several types of intussusception are distinguished; in the small bowel, enteric and ileocolic; in the large bowel, colic and ileocecal. A combined form is common, and is often reduced by barium enema. This series included 128 small bowel types (18 definitely enteric), 293 large bowel types (16 colic and at least 7 or 8 haustral or haustrocecal).

In very young children the late passage of blood usually indicated intussusception of the small bowel type, which has a bad prognosis.

The roentgen diagnosis is based on fluoroscopic findings during the injection of the enema, but the preliminary film often gives a good deal of information in the distribution of the gas shadows.

In treatment, emphasis is laid on the importance of correct pressure, up to two meters of barium column, and on repeated injections; manipulations through the abdomen are less important. Anesthesia is to be avoided. The criteria of reduction consist of complete filling of the cecum and reflux into the small bowel. Secondary operation on cases erroneously believed reduced carries considerable danger. In children under two years of age, the enema treatment is distinctly superior; in older children it is a satisfactory method, although its advantages are less clearly marked.

LEWIS G. JACOBS, M.D.

Acute Obstruction of the Colon. Differential Diagnosis Between Volvulus and Cancer of the Sigmoid Colon by Preliminary Roentgenogram. Joseph Levitin and Helen B. Weyrauch. Am. J. Roentgenol. 53: 132–141, February 1945.

The differential diagnosis between a slowly developing mechanical obstruction of the colon due to cancer of the sigmoid and that due to volvulus can be made at times from a plain roentgenogram of the abdomen.

Nine cases, including both types, are reported. In the presence of a cancer, since the obstruction is a slowly developing one, the colon accommodates itself by distending first in its thinnest part, the cecum. Later complete and relatively acute obstruction may supervene. The gas-distended colon can be visualized down to the point of obstruction, where a sharp interruption occurs. No large gas-filled loops are seen rising out of the pelvis. Volvulus of the sigmoid is caused by a sudden twisting of the sigmoid loop, so that it becomes a closed obstruction in relation to the rest of the bowel. The closed loop is rapidly distended with gas, rising out of the pelvis and occupying the middle of the abdomen. It may extend to the diaphragm. The volvulus may act as a mechanical block, resulting in dilatation of the colon proximal to it. The roentgen diagnosis depends upon the demonstration of this dilated loop of sigmoid.

L. W. PAUL, M.D.

Roentgenological Manifestations of Malignancy of the Colon. Lawther J. Whitehead. South. M. J. 38: 85–88, February 1945.

This is a short general discussion of roentgenologic criteria in malignant neoplasms of the colon. The author points out that there are 30,000 deaths from cancer of the colon or rectum yearly and quotes the statement of Case that at least 90 per cent of cases should be correctly diagnosed. This, however, requires experience and skill, patience, and dexterity. Rectosigmoidoscopy should precede roentgen examination and a report of the findings should be available to the roentgenologist in every instance. Many spot films should be taken in special positions. Double contrast films are desirable. Re-examination and confirmatory studies should be freely undertaken to reduce the chances of error. Malignant lesions of the colon are often multiple, as in cancer originating in polyps.

MAX MASS, M.D.

Cholelithiasis in Sickle Cell Anemia. H. Stephen Weens. Ann. Int. Med. 22: 182–191, February 1945.

Cholelithiasis is not infrequently observed in Negroes with sickle-cell anemia. Four cases of the latter condition in which gallstones were demonstrable roentgenologically are reported here.

The number of recorded cases of sickle-cell anemia coming to autopsy is comparatively small. The author found 44 fairly complete necropsy reports, and in 12 of the group gallstones were found postmortem or were removed surgically during the course of the disease. In none of the patients over forty were calculi observed. Anemia was not a characteristic feature of these latter cases, and it seems likely that they represented the so-called "sickle-cell trait." Eight of the 12 patients in whom cholelithiasis was observed were males.

Increased destruction of red blood cells is one of the characteristic features of sickle-cell anemia. On disintegration of the red blood corpuscles, hemoglobin is liberated and converted into bilirubin. Hyperbilirubinemia in these patients is the result of increased blood destruction. This phenomenon is common to both sickle-cell anemia and congenital hemolytic jaundice, in which latter condition Mayo observed the presence of cholelithiasis in two-thirds of a group of patients.

With the generally lower incidence of gallstones in the colored race, sickle-cell anemia may be a more important etiologic factor in the development of biliary calculi in the Negro than is generally appreciated.

Episodes of acute abdominal pain, usually localized in the epigastrium, occur frequently in sickle-cell anemia. As yet, the cause of these abdominal crises has not been satisfactorily explained. Hepatic infarcts, splenic hemorrhages, and nerve root pains due to vertebral changes have been suggested. That the crises are to be explained on the basis of biliary colic seems unlikely, since many patients with sickle-cell anemia do not have cholelithiasis, and in other cases the attacks have been known to continue after cholecystectomy.

Recognition of sickle-cell anemia as a cause of acute and chronic abdominal symptoms is important in order to avoid unnecessary operations. The mere presence of biliary calculi in a patient with sickle-cell anemia requires careful evaluation of all clinical symptoms before operation is advised, since it is commonly known that this disease increases the risk of surgical procedures.

STEPHEN N. TAGER, M.D.

Nursing: A Source of Error in Cholecystography. Olle Olsson. Acta radiol. 24: 489–494, Dec. 31, 1943. (In German.)

The author calls attention to a source of error in cholecystography with sodium tetraiodophenolphthalein. This dye is excreted in the milk of nursing mothers, reducing the amount of dye in the blood below the level necessary for demonstration of the gallbladder. A case is reported in which non-visualization was present during the nursing period, although both before and after this visualization was normal, and no change of symptoms had occurred. A second case is reported in which two attempts to visualize the gallbladder failed during lactation, but at operation, four days following the second examination, the gallbladder, liver, and pancreas were found to be normal.

LEWIS G. JACOBS, M.D.

Meckel's Diverticulum. M. E. Mottram and L. H. Garland. Am. J. Roentgenol. 53: 142–146, February 1945.

Meckel's diverticulum is an unobliterated remnant of the vitelline duct and is found in approximately 2 per cent of the population. It may vary a great deal in size, shape, and location. While anatomists describe it as arising from the terminal ileum, surgeons frequently find it at a much higher level, suggesting that the higher its location in the small intestine, the more likely is the possibility of surgical complication. The diverticulum may have walls identical in structure with those of the adjacent bowel, or one of the muscle layers may be absent. Heterotopic gastric or duodenal glands may be present.

Roentgen diagnosis of the smaller sacs (2.5 cm. in diameter) is rarely possible. Only about 21 cases have been reported in the literature as being correctly diagnosed prior to operation. In the case reported by the authors, roentgen study following a barium meal demonstrated a circular collection or pocket of the medium in the mid-abdominal area, about 5 × 9 cm. in size. The sac retained some barium for over twenty-four hours. At operation it was found 60 cm. from the ileocecal valve. Roentgen diagnosis of the larger sacs should be possible on careful gastro-intestinal examination.

L. W. PAUL, M.D.

THE MUSCULOSKELETAL SYSTEM

Degree of Kinship and Pattern of Ossification. A Longitudinal X-Ray Study of the Appearance Pattern of Ossification Centers in Children of Different Kinship Groups. Earle L. Reynolds. Am. J. Phys. Anthropol. 1: 405–416, December 1943.

The study here recorded was made to determine whether the patterns of appearance of skeletal epiphyses are more similar in related than in unrelated children. It is also concerned with the degree of kinship, attempting to show whether identical twins, for example, are more similar in patterns of ossification than are ordinary siblings or first cousins. Onset of ossification is defined as the estimated time at which an ossification center appears, as judged by its first visible shadow on the x-ray plate. The 38 centers chosen for this study were selected so as to be representative both anatomically and in time of appearance from birth to around 78 months. Four kinship groups were observed: identical twins (6 pairs), siblings (22 pairs), first cousins (8 pairs), unrelated children (9 pairs).

It was found that pairs of more closely related children tend to have onset patterns that are more similar; deviant centers which are more similar in time of onset to their corresponding centers; subgroups of ossification centers which are more similar in order of appearance. The ranking from greatest to least similarity in each instance was: twins, siblings, cousins, unrelated children.

This consistent hierarchy of resemblance points to some selective factor operating within the kinship groups. It is suggested that this selective factor is heredity operating upon both time and order of onset of ossification centers in the body.

Ossification Sequences in Identical Triplets. A Longitudinal Study of Resemblances and Differences in the *Ossification Patterns of a Set of Monozygotic* Triplets. Lester W. Sontag and Earle L. Reynolds. J. Heredity 35: 57–64, February 1944.

A study was made of the patterns of ossification in a set of monozygotic triplets whose external environment had been apparently quite similar and whose illness history during the period covered by the present study, with the exception of two isolated colds, had been the same.

Roentgenograms were taken at six-month intervals from the age of twenty-four months to fourteen and a half years. The patterns of onset of ossification of the 26 centers, selected on basis of availability, although very similar, nevertheless showed a number of differences. The rates of skeletal progress of these triplets changed so that their rank-order of onset of ossification centers was different at different ages. The greatest variation of time of onset was in the appearance of the centers for the metatarsals. The triplet who led in onset time for the majority of the other centers, particularly in the hand phalanges, was later than his brothers in the onset time of all the carpals studied. The triplet showing the least number of ossification centers present from 36 through 54 months passed his brothers in this respect at 60 through 72 months of age.

The authors conclude that certain environmental factors or acquired metabolic characteristics may be capable of modifying the genetic pattern of ossification.

Aseptic Necrosis *of the* Capital Femoral Epiphysis Following Adolescent Epiphyseolysis. Robert D. Moore. Surg., Gynec. & Obst. 80: 199–204, February 1945.

This article is a report of the gross and microscopic pathology in two cases of slipped femoral epiphysis and a review of the literature on similar reported cases.

The first patient was a 12-year-old boy who had a portion of the femoral head excised following avascular necrosis in a slipped epiphysis. The specimen demonstrated narrowing of the articular cartilage due to degeneration and endochondral ossification from below as the blood supply returned. Chronic inflammatory changes were present in the synovia.

The second patient was a 21-year-old male with non-union after complete separation of the right femoral capital epiphysis. The head was excised and an arthrodesis performed. The articular cartilage was largely necrotic and replaced by connective tissue from below and by fibrocartilaginous tissue and pannus from above. Only a small amount of the necrotic bone had been replaced by new bone. There were degenerative changes in the opposing acetabular articular cartilage.

The author points out that during the early growing period the articular cartilage is less dependent upon the circulation from the underlying bone and the synovia may furnish adequate circulation, so that in Legg-Perthes' disease, when endochondral bone ossification is resumed, the shadow of the articular cartilage, as seen in the roentgenogram, remains thickened. In slipped femoral epiphysis in the young adolescent, however, since growth is slower, much of the deeper zone of cartilage undergoes degeneration followed by endochondral bone replacement with a resultant actual decrease in thickness of the cartilage. In the first case there was considerable new bone formation in the area of necrotic bone; in the second case there was little.

The chronic inflammatory changes in the synovia, the author believes, are the result of mechanical derangement or decomposition products of necrotic bone and cartilage.

The paper is well illustrated.

FRANK P. BROOKS, M.D.

Aseptic Necrosis of the Epiphyses and Short Bones. Roentgen Studies. Howard P. Doub. J. A. M. A. 127: 311–317, Feb. 10, 1945.

The findings in aseptic necrosis as it involves the developing epiphyses and the primary centers of ossification in certain of the short bones are discussed. Short descriptions are given of the salient points of some of the more commonly observed lesions.

No general agreement has been reached as to the etiology of aseptic necrosis. That some form of trauma with secondary vascular occlusion of the involved area is responsible is held by many. Embolic occlusion has also been mentioned as a cause, and endocrine dysfunction has been invoked by others.

The pathologic process probably involves actual death of the ossifying nucleus, followed by fragmentation, irregular absorption of the involved bone, and replacement by so-called creeping substitution or recalcification. This is the same process that has been observed in adults, in whom aseptic necrosis is being increasingly recognized. The cartilage is in most instances not involved in the process. In general, the clinical findings are not prominent or acute, and there

may be no complaint except for slight pain and limping. There may be restriction of motion of the involved part.

The roentgen examination has been of the greatest aid in the study of the changing pathologic picture in these cases. In the earliest stages there are usually small areas of lessened density which, under observation, increase in extent and intensity. The epiphysis becomes fissured and fragmented and fuzzy in outline, with a ragged appearance. Areas of dense necrotic bone are visualized. The process may involve both the epiphysis and the metaphysis, and the former may be compressed and flattened. In the stage of regeneration or recovery there is a gradual loss of the osteoporosis with absorption of the dense necrotic bone in the epiphysis. This is followed by slowly advancing replacement of the necrotic bone by recalcification, which proceeds until there is complete bony restitution.

The amount of deformity of the restored bony contour depends on many factors, including the stage at which the condition was first recognized and adequate treatment applied. The duration of treatment also plays a role. Some patients refuse to allow the involved part adequate rest after the symptoms have disappeared. It should be recognized that there is a definite lag in bony replacement as compared with the disappearance of symptoms. Many patients have a definite sense of well-being at a time when the roentgenograms still show necrosis and very little evidence of regeneration.

Roentgenological Early Symptoms and Healing Phenomena in Chronic Rheumatic Arthritis. Folke Knutsson. Acta radiol. **24:** 121–134, April 30, 1943. (In English.)

Articular decalcification is described as an initial roentgenologic symptom of chronic rheumatic arthritis. Another early manifestation is juxta-articular periostitis. This, Knutsson says, he has not found mentioned in the literature, and to our knowledge he is the first to describe it. The earliest roentgenological changes are, as a rule, noticed in the bones of the hands and feet. The proximal point of the little toe is a favorite site. The subsequent development is characterized by destruction of cartilage, leading to diminution of the joint space, and by ulceration. If healing occurs, the ragged contours produced by ulceration disappear and an even bone outline ensues. The destructive type of arthritis is thus transformed to a deforming type. Another healing process results in osseous ankylosis in consequence of total destruction of cartilage.

E. A. SCHMIDT, M.D.

Report of Injuries Among Survivors of an Airplane Crash. John S. Thiemeyer, Jr. U. S. Nav. M. Bull. **44:** 241–246, February 1945.

Fifteen of 29 persons survived an airplane crash at sea. They were rescued after twenty-three hours on life rafts; one died seven hours later, and the remainder reached a hospital three days after the crash. Eleven of these had sustained 22 fractures, involving the cervical and thoracic vertebrae, ribs, humerus, scapula, clavicle, radius, fibula, metatarsals, and mandible. Careful study of the fracture lines and the mechanics of production of the fractures indicated that they were due to counteracting muscle pull upon the bones rather than to direct trauma. This was particularly true of fractures of the humerus and scapula. The author points out the need for repeated x-ray studies when fractures of the vertebrae are suspected.

BERNARD S. KALAYJIAN, M.D.

Diagnosis of Fracture of the Ribs, Scapula, Sternum and Mandible. James W. Lewis. Mil. Surgeon **96:** 175–177, February 1945.

In roentgenography of the ribs or other parts having overlying, interfering structures, the author has found that better detail will be obtained by the use of a short focal-film distance. For the ribs, for example, the film is placed as close to the particular region to be demonstrated as possible, eliminating the Bucky diaphragm. The tube is then placed close to the opposite side of the body, touching it if the equipment permits. If feasible, an immobilization band is drawn tightly across the chest. When the posterior ribs are being examined, the patient is instructed to breathe normally, as the motion of breathing moves, and thus blurs, the anterior ribs and lung tissue. With the chest immobilized and with the patient supine, the posterior ribs will be practically motionless. When the anterior ribs are being studied, the patient must stop breathing. With such a short focal-film distance, the image of the ribs tends to be distorted. This may be compensated for to some extent by means of a very small focal spot. Since the Bucky diaphragm is not used, a comparatively low voltage (38 to 42 kv.p. is optimum for the ribs) is necessary to improve the contrast of the film. This method is successful for ribs above the diaphragm only.

Examination of the mandible is simple and should require only a few minutes. The patient sits upright, with his head in normal position, and holds the film lightly against the cheek. Since the tube must be brought close to the opposite cheek, it is obvious that a cone cannot be used. To overcome this difficulty, a diaphragm has been constructed which is placed in the cone slot. The diaphragm may be made from a piece of thin lead by cutting a hole just large enough to permit the ray to cover the desired area at a set distance—the distance from the focal spot to the film. The optimum voltage is 50 kv.p.

For the short focal-film method, the part to be demonstrated must be close to the film and the part to be blurred close to the focal spot, with the two parts at some distance from each other. A small focal spot and a very low voltage must be employed.

Investigation of Sciatica and Lumbago—Radiological Aspect. James F. Brailsford. Brit. J. Radiol. **17:** 308–311, October 1944.

The evaluation of evidence in the investigation of low-back pain is one of the most difficult of clinical tasks. The causes are many and variable, including maldevelopment, injury, inflammation, and new growths in the skeletal, nervous, gastro-intestinal, vascular, and genito-urinary systems. Thorough investigation of all possible sources is essential before any major surgical procedure is undertaken.

The present paper is concerned primarily with the value of radiology in actual lumbosacral lesions. Only a small proportion of patients with low-back pain have lesions in the lumbosacral region demonstrable in the early stages by x-ray. This, however, does not justify the omission of roentgenography, as many lesions of

grave importance are first revealed through that agency. In certain recurrent cases, the primary examination may be negative, while subsequent studies show lipping of the borders of the vertebrae or articular facets, indicating that an inflammatory process has been going on.

Irregularities of development in the lumbosacral region are common and are frequently discovered in examinations of the urinary and digestive tracts. These are usually unassociated with symptoms but may later give rise to difficulties. Thus, asymmetrical development of the body or transverse processes of the fifth lumbar vertebra, or of the lateral mass of the first sacral vertebra, though usually asymptomatic in adolescence, may become troublesome with the strains of adult life.

Hypoplasia of the neural arch of the fifth lumbar vertebra and failure of fusion of the elements between the articular processes are sometimes seen in association with spondylolisthesis. The latter condition occurs frequently in young women, in whom it may seriously interfere with parturition.

Some lumbosacral lesions are associated with generalized bone disease, as rickets, Paget's disease and hyperparathyroidism. In such cases the upper segments of the sacrum may become almost horizontal and the lower segments flexed, resulting in a lordosis.

The lumbosacral area is prone to injury in falls, crushes, and lifting of weights. The results of these injuries may show no evidence on x-ray examination, as many are muscular and ligamentous. With severe degrees of trauma to the bones or ligaments, though no change can be detected by roentgenography during the first few weeks, later reactive changes are demonstrable—some degree of localized osteoporosis, followed after two or three months by ossification of the ligaments.

Sometimes pre-existing diseases such as tuberculous caries, syphilitic gummata, and bone tumors are first seen after trauma, having been previously symptomless.

Lesions of the intervertebral disks may be recognized in the plain roentgenogram by calcium deposits, by narrowing of the intervertebral space, and by certain deformities in the vertebral bodies, while protrusions from the disk into the spinal canal can be detected only with the aid of lipiodol or other contrast medium. The author warns against indiscriminate surgery in disk lesions.

SYDNEY J. HAWLEY, M.D.

Anatomical Investigations on the Distribution of Epidural Fat in the Lumbar Spine: Contribution to Myelographic Differential Diagnosis. Helge Sjövall. Acta radiol. 24: 177–182, June 15, 1943. (In German.)

The purpose of the author's investigations was to determine whether or not the presence and distribution of epidural fat might be a confusing factor in the diagnosis of prolapse of the intervertebral disks. Postmortem examination of 25 lumbar spines showed (1) abundant fat accumulation segmentally arranged in the posterior areas; (2) some fat coating in lateral distribution; (3) no fat in the ventral epidural space from the 4th intervertebral disk upward and only a poorly developed microscopic fat layer ventrally at the height of the 5th intervertebral disk. Only in this latter area may epidural fat interfere with the myelographic diagnosis of prolapse of the intervertebral disk.

E. A. SCHMIDT, M.D.

Should Non-Traumatic and Non-Inflammatory Changes in the Spine Be Compensable? John D. Ellis. Am. J. Surg. 67: 391–400, February 1945.

The present tendency to award compensation for total permanent disability to older workmen who claim an aggravation of ancient hypertrophic changes about the spine and spinal joints presents one of the commonest abuses of our legal system. There are two reasons for this. The first is the confusion of terminology inherent in the discussion of degenerative and inflammatory conditions, with no strict differentiation in texts on pathology between the invasion of tissues by infecting organisms and tissue changes resulting from mechanical trauma. The second arises out of the very nature of present-day legal procedures. Nothing fits in so well with our system of cross-examination as an attack by the examiner on a subject concerning which the terminology is confused. The surgeon is unable to explain clearly to a lay jury what pathological conditions are traumatic or influenced by trauma and what is perhaps degenerative or hypertrophic, reconstructive or functional, and wholly unaffected by trauma.

Chronic affections of the joints have been divided into two great groups (1) rheumatoid arthritis, atrophic arthritis, infective arthritis, etc., and (2) osteoarthritis, hypertrophic or degenerative arthritis, etc. This paper is concerned with the conditions falling in the latter group. Physicians interested in the role played by trauma must definitely disregard any such prevalent terms as osteoarthritis, degenerative arthritis, and hypertrophic arthritis in the description of diseases which are not inflammatory in nature. The author believes that the nomenclature accepted in all continental medical literature should be employed, using "arthrosis" to emphasize the non-inflammatory nature of hypertrophic and osteoarthritis and "spondylosis" in preference to spondylitis for all non-inflammatory or degenerative affections of the vertebral bodies themselves. The chronic nature of these conditions can be determined with certainty by systematic physical and roentgenological examinations.

Roentgenographic Demonstration by Tantalum Powder of Sinuses Resulting from Extraction of Intervertebral Disc Protrusions. Carl J. Graf and Wallace B. Hamby. Am. J. Roentgenol. 53: 157–160, February 1945.

In order to demonstrate the sinuses that remain following removal of protrusions of the lumbar intervertebral disks, the authors have employed tantalum powder. At the time of operation a curette cup full of the powder (double this amount is now used) is introduced into the disk sinus. Roentgenograms made postoperatively show the sinus as an elongated slit extending toward and in some cases to the anterior part of the annulus fibrosus. Follow-up roentgenograms after as long an interval as seven months have shown no significant alteration in the appearance. Histopathologic study in one case, six weeks after implantation of the powder, showed only mild reactive changes.

L. W. PAUL, M.D.

"Os Acetabuli" and Other Bone Nuclei; Periarticular Calcifications at the Hip-Joint. Göran Zander. Acta radiol. 24: 317–327, Aug. 31, 1943. (In English.)

The author points out that, strictly speaking, the term os acetabuli is synonymous with os cotyloideum

The paper concludes with the statement that if intravenous injection occurs, no more oil should be injected at any time, repeated films of the lungs should be made until all the oil is gone, and expectant treatment should be given, with forcing of fluids.

MAX MASS, M.D.

Thoracopagus Twins—X-Ray Diagnosis. Edward A. Graber. Am. J. Obst. & Gynec. 49: 276–279, February 1945.

A case of thoracopagus twins is reported. The diagnosis was not made until failure of delivery after hard labor forced an exploration of the vagina and uterus. A destructive operation was performed on the fetus after several unsuccessful attempts to deliver it.

Although an antepartum diagnosis of twins was made by x-ray, the abnormality was not suggested. The author feels that had thoracopagus twins been considered when the roentgen studies were made, certain features on the films might have suggested an antepartum diagnosis. These were as follows:

1. The heads were at the same level. In almost all cases of twins, the heads are at different levels.
2. The head of one of the twins did not face to the front, but was turned to the side. This indicated that the babies were so close together that they could not face each other.
3. The hand of one baby was over the shoulder of the other and the arm of one was around the body of the other. This could have indicated that the babies were in the same amniotic sac.

The advantages of an antepartum diagnosis are obvious.

STANLEY MACHT, M.D.

THE GENITO-URINARY SYSTEM

Notes Regarding Intravenous Urograms, Based on 2,000 Series in Eighteen Years. Walter Pritchard. J. Urol. 53: 387–392, February 1945.

Any patient whose vein can be entered, who is producing a fair amount of urine, and whose systolic blood pressure is over 80, is considered a suitable candidate for excretion urography. Preparation consists in dehydration by abstinence from fluid for eighteen hours and omission of breakfast. Purgation and enemas are not helpful.

The author considers the "standard" dosage of dye inadequate and gives double or treble that amount. Since the useful portion of the dye is iodine, the injection should be measured in grams of iodine rather than cubic centimeters of dye. The 20-c.c. ampule of 35 per cent diodrast contains approximately 7 gm. of iodine; 30 c.c. of 50 per cent neo-iopax contains twice as much. The amount of dye injected is proportionate to the patient's weight, age, and concentrating power. Children up to puberty advantageously handle twice as much iodine as adults per weight proportion; infants, three times as much. The poorer the patient's renal function, the more iodine he must have to produce satisfactory urograms. The author measures the specific gravity of a concentrated urine specimen to estimate renal function prior to urography. Poorly concentrating kidneys may yield a satisfactory urogram if there is at least 25 gm. of iodine in the blood. Ideal density requires 4 per cent iodine in the urine. The only disadvantage of moderate overdosage of dye is expense. When one is dealing with a nearly occlusive ureteral stone, excellent urograms are obtained hours after injection.

In order to obtain a peak plateau of concentration, the author injects the dye within one to two minutes. The forearm is preheated to induce hyperemia which will dilute the dye rapidly and decrease pain and intimal damage. Vein cramp warns of the latter hazard.

The higher concentration dyes, unless injected very slowly, produce more vein cramp and thrombosis. The patient often has aching extending to the shoulder during and two minutes after injection. Most patients have a sensation of warmth and thirst. Allergic patients may complain of slight precordial tightness, nausea, and rarely asthmatoid reactions. Symptoms appear more from fright than from iodine.

Following injection the patient is placed in the 15-degree Trendelenburg position, to which he is returned between exposures. The first exposure, three minutes after injection of the dye, is usually made in the Trendelenburg position with an inter-renal focus. It is followed by a second with umbilical focus and deep inspiration immediately after leveling, to free the kidneys from the rib margins and liver. These films are inspected and the technic modified as indicated, following which an upright exposure is made and bladder studies are done if required. A large compression binder is applied for two minutes for supplemental views in patients with large amounts of gas.

Interpretation can best be done by the urologist in charge. A roentgenologist can see an obvious stone and its backed-up ureter; however, much may be missed by failing to obtain repeated standing views and by not following up clues and correlating x-ray with cystoscopic and clinical data.

The intravenous technic is relatively innocuous. The author resorts to retrograde pyelography in no more than 2 per cent of cases.

CHARLES R. PERRYMAN, M.D.

Injuries of the Kidney. James C. Sargent. J. Urol. 53: 381–386, February 1945.

In a refreshingly succinct paper, graced by excellent English, the author urges consideration of renal trauma in every case of serious body injury. With the diagnosis in mind, the examiner will then be able to contribute materially to a reduced mortality from ruptured kidney.

Gross hematuria is the sign demanding prompt urologic investigation. The author feels strongly that retrograde pyelograms are far superior to intravenous urograms in indicating the anatomic damage and cites some cases to substantiate this.

Treatment for small tears of the kidney, in which the architecture is fairly well preserved, is masterful inactivity, since recuperative power is very high in such instances. Extensive rupture, in which the pyelogram reveals very little if any semblance to a normal pelvis, demands immediate nephrectomy.

EDWIN L. LAME, M.D.

Renal Tuberculoma and Tuberculous Perinephric Abscess. John A. Benjamin and Hobart L. Boyd. J. Urol. 53: 265–268, February 1945.

The authors report a case of tuberculoma of the left kidney associated with a tuberculous perinephric abscess in a 29-year-old Italian housewife. Six weeks before admission (September 1939) she suffered from

nausea, vomiting, frequency, and dysuria with associated left costovertebral pain and fever. She had lost twenty-four pounds within the last two months and had been in contact with a sister who had active pulmonary tuberculosis.

Physical examination was essentially negative except for left costovertebral angle tenderness. Acid-fast stain of the urinary sediment showed *Mycobacterium tuberculosis.* Fluoroscopy revealed restricted movement of the left diaphragm, and in a film of the abdomen the left psoas shadow and medial outline of the left kidney were indistinct. For these reasons a left perinephric abscess was suspected. Cystoscopy was negative and intravenous and retrograde pyelography showed deformity of the left kidney pelvis compatible with a diagnosis of tumor or cyst.

Sixteen days after admission, exploration was undertaken, and a left perinephric abscess was drained. Acid-fast organisms were found in the smear. In January 1940, a left nephrectomy was done and a large necrotic area enclosed by a thin superficial membrane was found at the upper pole of the left kidney. Histologically this area showed characteristic tuberculous lesions.

The patient was discharged in April 1940 and was readmitted in April 1942 with a salpingitis which proved not to be tuberculous. Later her health declined gradually and she died of tuberculous peritonitis in December 1943. N. P. SALNER, M.D.

Ureteral Syndromes in the Male: Analysis of 100 Cases. Isidor E. LeDuc. J. Urol. 53: 295–318, February 1945.

The ureteral syndrome consists of a group of related complaints: pain of renal or ureteral distribution or both, with urgency of urination due directly to the development of such pain as the bladder fills. One hundred cases were analyzed and the patients were grouped in five categories, depending upon the predominating complaints, namely, renal pain, enuresis, "appendicitis," testicular pain, and pyuria. Renal pain is believed to be due to mild stasis, and ureteral pain to depend upon the location of structural or physiological departures from the normal.

Intravenous urography is not considered suitable for the study of the condition, retrograde pyelography being preferable. Certain of the cases show a definite narrowing of the ureter with irregular caliber and with dilatation and stasis above these points. In others, the evidence points to a dysfunction of the autonomic nervous system. The diameter of each ureter is measured in millimeters, and dilatation is classified as borderline or mild if the figure is from 5 to 8 mm., moderate if from 8 to 10 mm., and severe if 1 cm. or over. Elongation of the ureter is common, with distortion of the normal course. A rather characteristic finding is mild to moderate blunting of the calices. Most of the cases cannot be classified simply as stricture of the ureter.

Almost invariably there is costovertebral tenderness on one or both sides or tenderness over one or both ureters. At cystoscopy one can reproduce the pain by filling the renal pelvis and by passing a bulb-catheter. The evidence indicates that infection in these patients is apt to be secondary.

The most effective therapy has been a combination of cystoscopic treatments aimed at dilating the ureter or enlarging the ureterovesical orifice, plus the use of antispasmodics of the belladonna-hyoscyamus group, and the eradication of local or focal infection.

DAVID KIRSH, M.D.

Pathologic Lesions Associated with Ectopic Termination of Supernumerary Ureters: Report of Three Cases. Samuel K. Bacon. J. Urol. 53: 402–407, February 1945.

Ectopic termination of a supernumerary ureter is a rare anomaly, predisposing to lesions of the upper urinary tract. Up to 1942, approximately 300 cases had been recorded. The ureteral wall is thickened, and the conduit is tortuous and dilated. The corresponding renal segment is hypoplastic or hydronephrotic. Pyonephrosis and pyoureter usually coexist. In women, in whom the condition is more common, the aberrant ureter generally terminates in the vaginal vestibule, vagina, or urethra, and the diagnosis is suggested by a history of incontinence since birth, with normal voiding. In males the stoma is usually in the posterior urethra, and incontinence does not occur, being prevented by the external sphincter.

Catheterization and pyelo-ureterography of the ectopic conduit are the most conclusive diagnostic procedures. The subsequent cystoscopic finding of a single meatus on the same side of the bladder should lead to immediate investigation of the urethra. In the author's experience, each orifice was visualized and with one exception retrograde pyelography demonstrated the associated pathologic lesion. In one of his cases, resection of the cranial segment of the kidney and two-thirds of its ureter could be done. In the two remaining cases, nephrectomy was performed because a single arterial supply precluded partial resection. All three patients recovered completely.

FRANCISCO BASSOLS, M.D.

On the Diagnosis of Rupture of the Urinary Bladder. Olov Fr. Holm. Acta radiol. 24: 198–205, June 15, 1943. (In English.)

The author describes three cases of rupture of the urinary bladder following accidents. The roentgenographic procedures included general abdominal examination, to determine or exclude intra-abdominal fluid or free gas, and intravenous and retrograde cystography. Retrograde cystography is preferred by Holm, but the danger of air embolism must be considered if air is used as a contrast medium. With regard to the differential diagnosis between intraperitoneal and extraperitoneal ruptures, the author states that in the absence of pelvic fracture the rupture is practically always intraperitoneal while, if the pelvis is fractured, the rupture is probably extraperitoneal. Rupture of the bladder is always to be considered a serious injury, accompanied by a high mortality. E. A. SCHMIDT, M.D.

CONTRAST MEDIA

The Mixing and Flowing Capacity of Water-Soluble Contrast Media in Vascular and Cardiac Investigation. Sven R. Kjellberg. Acta radiol. 24: 433–454, Dec. 31, 1943. (In German.)

The demonstration of the blood vessels is in the final analysis a roentgenologic problem; the prospect of adequate study with water-soluble media was received with the greatest enthusiasm. However it

was soon discovered that such media had a tendency to "settle out," due to the high specific gravity of the solutions used. This property, which can be reduced by dilution, has led to certain inaccuracies of interpretation of past experiments.

The miscibility of a fluid with water or body fluids is actually dependent on a number of factors, of which the specific gravity is most important. The relative viscosities are also of great importance, while surface tension and diffusibility are of slighter significance. In examination of the vascular system the contrast medium is not placed in a quiet fluid, but in a stream of variable velocity. The question of what effect this has was studied by an experimental system of tubes. The experiments showed that layering, especially along the walls, can readily occur. This effect is seen in some roentgenograms of human subjects printed for comparison. These layers do not necessarily follow a straight course, but produce a wavy pattern in the vessel. There is a tendency to form irregular shadows closely simulating a thrombus defect. Furthermore, the progressive dilution of the medium makes the visual demonstration of the vascular tree less and less sharp.

Some associated studies on the heart were also undertaken, covering both the mixing of the contrast medium in the heart and the demonstration of the passage of the medium through the atrioventricular valves. The studies included observations on a two-chamber model heart and *in vivo* experiments on rabbits and dogs, in which thorotrast was used for a contrast medium. It was shown that the first part of the medium to enter the ventricle has a pale, thin consistency and lacks definition, which makes it impossible to use this method accurately to determine the exact site of the anterior end of the column, the exact site of entrance of the medium into the heart, or the distance the medium travels in a fixed time. The exact moment of opening and closing of the valves, therefore, cannot be determined by this means. The rapid heart rates of the experimental animals increased the unsharpness of the valve shadows, but even with exposures of 1/50 second they were unsatisfactory.

LEWIS G. JACOBS, M.D.

ROENTGEN THERAPY

Two-Year Experience with Roentgen Contact Irradiation. Sven Hultberg. Acta radiol. 24: 328–338, Aug. 31, 1943. (In German.)

With a Philips-Metalix contact unit (50 kv., 2 ma., 0.2 mm. Al effective wall filter, 2 cm. F.S.D., 10,600 r/min.) the depth dose was found to be about 20 per cent at 1 cm. In treating superficial carcinoma a depth dose of 2,000–3,000 r is needed for a cure. An air dose not exceeding 15,000 r was therefore used. This leads to an immediate reaction (*Sofortreaction*) consisting of slight erythema and edema of the skin which lasts for a few hours to half a day. The erythema may be more persistent, especially after higher doses. The growth begins to regress by absorption after five to seven weeks. Sometimes a slight pigmentation persists for a couple of months. Of 208 patients with primary carcinoma (175 of the skin, 33 of the mucosa), 207 showed primary healing and one was lost from observation. There were 5 recurrences in the first year, all of which responded to further therapy Satisfactory results were also obtained in a large variety of other conditions, including mycosis fungoides, malignant melanoma, warts, keloids, cavernous hemangiomas, condylomata acuminata, cutaneous tuberculosis, chronic tonsillitis, and tonsillar hypertrophy. LEWIS G. JACOBS, M.D.

Results of Treatment of Cancer of the Breast at Centrallasarettet in Borås, Sweden. Bengt A. Nohrman. Acta radiol. 24: 478–483, Dec. 31, 1943. (In English.)

This study is based on cases of mammary cancer treated from September 1931 to March 1941. The patients surviving were last examined in February and March 1943. The 205 cases are divided into three groups on the basis of treatment: (1) radical operation plus complete x-ray treatment; (2) nonradical operation; (3) inoperable.

Preoperative treatment consisted of three or four applications of 300 r (205 kv., filter 0.5 mm. Cu and 1.0 mm. Al, 40 cm. focal distance) to each of two fields in six to eight days. Through field I the breast was irradiated from an anterior oblique projection; field II included the breast and axilla and irradiation was directed laterally. When this treatment was given preoperatively only, similar dosage was applied to the axilla posteriorly. Operation followed in three to six weeks, depending on the skin reaction. Postoperative treatment was started as soon as the patient's condition permitted, usually in one to two weeks. Two series were usually given, with an interval of two months, each consisting of eight daily treatments. Two fields were covered: the anterior, including the operative area, supraclavicular region, and axilla; the posterior, including the supraclavicular region and axilla only. The anterior field was given 200 r × 5 (180 kv., filter 4 mm. Al, 50 cm. focal distance); the posterior 300 r × 3 (205 kv., filter 0.5 mm. Cu and 1.0 mm. Al, 40 cm. focal distance).

Group I consists of 154 cases, including 23 in which operation was done in other institutions. Of this group 48 ± 5.5 per cent were alive without carcinoma after five years; 1 ± 1.2 per cent were alive with carcinoma. The remainder were dead. No significant difference was shown between those receiving preoperative radiation, postoperative radiation, or both. Of those with axillary node involvement at operation, 26 ± 6.6 per cent survived five years, while of those without such involvement 74 ± 6.6 per cent survived, a highly significant difference. The end-result was not materially different in medullary and scirrhous forms.

Group II included 8 patients, of whom 5 survived five years and 2 for nine years or more.

Group III, 46 patients, received roentgen treatment only: 11 ± 5.2 per cent survived five years, but half of these died within the next two years. Although the corresponding figure for operated cases (with axillary extension) is 26 ± 6.6 per cent and not definitely significant, there is considerable probability that the operation adds to the salvage rate.

LEWIS G. JACOBS, M.D.

Roentgen Treatment of Carcinoma of the Larynx and Hypopharynx and Its Results. S. Mustakallio. Acta radiol. 25: 13–32, Feb. 29, 1944. (In German.)

A total of 201 cases of carcinoma of the larynx and 37 cases of carcinoma of the hypopharynx were observed at the Central Institute for Radiation Therapy in Helsinki (Finland) during the years 1936 to 1943. With a single exception, these were treated by x-rays (180 kv., 4 ma., tin filter, 40 cm. distance, field size 6 × 8 or 8 × 10 cm.), daily doses of 250 to 300 r/skin being given to two opposing fields up to a total of 6,000 to 7,000 r/skin within one month.

Five-year cures were obtained in 21 (32 per cent) of 66 patients suffering from carcinoma of the larynx, while only 1 patient out of 12 with carcinoma of the hypopharynx was free of symptoms after five years. Metastases recognized prior to the institution of irradiation did not exercise any considerable influence on the results of therapy. In cases in which tracheotomy had been performed prior to irradiation, the results were about the same as those obtained in Stage III carcinomas. F. ELLINGER, M.D.

Method of Roentgen Treatment of Mediastinal and Pulmonary Tumors. Erik Lundström. Acta radiol. 24: 462–468, Dec. 31, 1943. (In German.)

Since the position of the thoracic organs is somewhat variable, the author plans the treatment of intrathoracic neoplasms by first taking a plaster mold of the thorax at the level of the tumor and transferring it to a paper. The position of the growth and of the organs is then plotted, with the aid of roentgenograms in various positions and orthodiagrams, and the beams are directed onto the body on the basis of this plan, using a mechanical caliper for centering. [A hard way to do it!—L.G.J.]

In the treatment of bronchial carcinoma pneumothorax on the diseased side is recommended, since, with collapse of the lung, the mediastinal nodes and growth are brought closer together and therefore receive a more equal dose. LEWIS G. JACOBS, M.D.

Roentgen Diagnosis and Radiation Therapy of Sarcoma of the Stomach, with Special Consideration of Lymphosarcoma and Reticulum-Cell Sarcoma. Gösta Forssman. Acta radiol. 24: 343–373, Oct. 31, 1943. (In German.)

After reviewing the pathology and clinical aspects of sarcoma of the stomach, the author gives the case histories of 9 patients treated at the Radiumhemmet in Stockholm. The series included 4 reticulum-cell sarcomas, 2 lymphosarcomas, and 1 case each of plasma-cell sarcoma, fibrosarcoma, and myosarcoma. The differential diagnosis between these and other tumors of the stomach is discussed.

Preoperative roentgen treatment is considered desirable but in some instances is impossible due to diagnostic difficulties. Operable cases were treated by gastric resection and postoperative irradiation (0.5 mm. copper or tin filtration; 50 to 60 cm. distance). The daily doses varied between 250 and 400 r measured on the skin and the total doses amounted to 2,500 to 3,000 r (skin) delivered within four to six weeks to each of 2 anterior and posterior fields. Supplementary series were given two or three months later in some cases. Of 7 patients with gastric sarcomas which were considered radiosensitive, 3 died within the first two months, while 4 had remained symptom-free eight, seven and one-half, two, and two and one-half years, respectively.

Of interest are some measurements, made by the author in collaboration with Dr. Robert Thoraeus, of the x-ray dose in the cavity of the stomach of patients during roentgen diagnosis. Under the experimental conditions (86 kv., 200–250 ma., field 24 × 30 cm., 1.0 mm. Al filter, 70 cm. focus-skin distance) it was found that only 1.6 per cent of the skin dose (skin of the back) reaches the gastric cavity. F. ELLINGER, M.D.

Recurrences After Radiation Therapy of Carcinoma of the Uterine Cervix. Sven Hultberg. Acta radiol. 25: 59–80, Feb. 29, 1944. (In German.)

A total of 458 cases of carcinoma of the cervix were observed in the Radiological Clinic of the University of Lund (Sweden) during the years 1927–37. Of these, 451 received radiotherapy. Up to 1932, treatment was exclusively by radium according to the Radiumhemmet (Stockholm) technic. From 1933 on, combined therapy with radium and roentgen rays was employed. One hundred and forty-four patients, or 31.4 per cent, were symptom-free after five years.

The author's study of recurrence was based on 535 patients treated during the years 1927–39. Of these, 281 were symptom-free for various periods following treatment. In 90 (32 per cent) of these primarily symptom-free cases, there was eventual recurrence. Twenty-five per cent of the recurrences involved the cervix, the portio, or the fornices; 17 per cent the parametrium and the pelvic wall. Local recurrences associated with metastases elsewhere were seen in 33 per cent of the series, and recurrences in other areas than those mentioned occurred in 19 per cent. In 6 per cent of the cases the recurrences could not be localized. Sixty per cent of the recurrences were observed within two years of treatment, and 84 per cent within three years. Only 7 per cent are classified as late recurrences, *i.e.*, after five years.

Of 16 patients on whom hysterectomy was performed following irradiation, 12 were symptom-free three to eight years after operation. On the basis of this admittedly small number of observations, the author discusses the possibility of reducing the risk of recurrence by radiation therapy followed by surgical intervention on a larger scale. F. ELLINGER, M.D.

Radiation Therapy in Chronic Leukemia. T. G. Clement. Illinois M. J. 87: 84–88, February 1945.

The response of chronic myeloid and lymphatic leukemia to short-wave radiation is explained on a cytologic basis. In the order of their sensitivity to the action of such radiation, lymphoid cells come first, followed by polymorphonuclear leukocytes or bone marrow cells. All other cells and tissues are more resistant.

The first consideration in treatment of the chronic leukemias is the physical condition of the patient. Thus, the discomfort due to enlargement of the spleen should receive attention before the laboratory findings, of which the patient is unaware. Slow and careful irradiation will "slowly, it is true, but surely" relieve the symptoms. Avoidance of radiation sickness by the use of small initial doses is of paramount importance. If this precaution is not observed, the patient, instead of being moderately comfortable, becomes definitely ill, with a pernicious mental association of treatment with radiation sickness.

The first dose, usually given over the spleen, should not exceed 100 r. The author finds 75 r sufficient in most cases (135 kv.p., 6 mm. Al filtration). A second treatment is given after a week or ten days, and subsequent treatments are spaced in accordance with the symptomatic response or modification of the blood picture. The second treatment may be given to the marrow of one of the long bones or, if there is sternal pain, over the sternum, or the spleen may be treated again. After three or four treatments an accurate estimation of the patient's susceptibility to therapy may be made and a proper plan of action formulated.

In chronic lymphatic leukemia, enlarged lymph nodes usually call for attention first, either for cosmetic reasons or because they are producing symptoms, the main consideration here, also, being to the patient's comfort and well-being. Enlarged nodes distant from the treated areas often regress spontaneously. As in myeloid leukemia, the dose is kept down to 75 or 100 r, and a single area is treated initially.

In the ensuing discussion, the author stated that over a 17-year period he had 12 patients with leukemia who lived 12 years and 5 who lived nearly 15 years.

LESTER M. J. FREEDMAN, M.D.

RADIATION EFFECTS

Fluoroscopic Hazards, Including Use of Unprotected Radiographic Screens. Charles F. Behrens. U. S. Nav. M. Bull. **44:** 333–340, February 1945.

The author states very clearly the dangers of fluoroscopy. He has shown by careful measurements the total amount of radiation which will be received by the patient under different fluoroscopic conditions, as well as the amount which can be expected to be received by the operator. In addition to measurements on the ordinary fluoroscopic machine, he checked the amount of radiation which would pass through an intensifying screen in a cassette, since these have been used for emergency fluoroscopic work. Under such conditions, the operator would be without the protection of the lead glass normally present on a fluoroscopic screen. It is believed that such a set-up should be used only in extreme emergencies and then for only very short exposures and that under no conditions should it be employed as a routine measure.

The author recommends many protective measures, most important of which are: (1) good dark adaptation of the eyes; (2) use of moderate current: 75 kv.p. and not over 4 ma.; (3) intermittent exposure; (4) keeping the size of the field small; (5) keeping the hands out of the direct x-ray beam; (6) use of aluminum filtration; (7) use of lead-impregnated apron and gloves; (8) use of dental film as a test for amount of exposure; (9) frequent blood counts of the operators; (10) good ventilation of the fluoroscopic room. He warns against the use of any fluoroscopic apparatus by untrained personnel.

BERNARD S. KALAYJIAN, M.D.

Subsequent Degenerations after Fractional Protracted Roentgen Irradiation. Olof Sandström. Acta radiol. **24:** 289–294, Aug. 31, 1943. (In English.)

In evaluating new forms of radiotherapy, it is necessary to take into account the late changes which may appear. The time factor must be considered in relating damage to dose. Zuppinger's numerical estimate (Strahlentherapie **70:** 361, 1941 and **71:** 183, 1942) is used here for this purpose. For example, if a 20-day distribution of dose is taken as unity, a 40-day distribution will permit a dose 1.3 times higher. Zuppinger's general conclusions are cited, as follows:

1. Five years is insufficient for evaluation of damage, both degeneration and improvement occurring after that time.
2. The degree of primary damage is not well correlated with the degree of late damage.
3. Individual sensitivity variation is ± 15 per cent.
4. The skin of women is 20 to 25 per cent more sensitive than that of men.
5. Tissues will tolerate operation after fractional protracted irradiation.
6. A dose of 3,300 r in 20 days leads to no definite late degeneration; 3,900 r in 20 days is the dose for epilation and moderate telangiectasis; 4,600 r or over in 20 days leads to skin atrophy and induration.
7. Atrophy of the lymphoid tissue at the base of the tongue appears readily but persists only with doses above 4,500 r. Telangiectasis of the vocal cords appears after 3,200 r, but mucosal edema and induration only with doses in excess of 4,500 r.

The author reports five cases treated with the following factors: 164 kv., 4 ma., Thoraeus filter, 60 to 70 cm. F.S.D., h.v.l. 1.7 mm. copper, intensity 5 r/min. on the skin and 3 r/min. in the tumor.

In Case 1, a squamous carcinoma of the hypopharynx, the skin dose was 4,500 r and the tumor dose 4,600 r. Two years after treatment telangiectasis of the vocal cords developed, and after five years the epiglottic mucosa was atrophic and pale. The "reduced tumor dose," *i.e.*, reduced to fractionating over 20 days, was 3,500 r. In Case 2, a cancer of the epipharynx with cervical metastases, a tumor dose of 6,200 r was given, a skin dose of 3,600 r, and a skin dose to the cervical lymph nodes of 5,200 r. The "reduced doses" were 4,100 r, 2,400 r, and 3,900 r, respectively. After seven years the only damage was a slight telangiectasia of the neck fields. Case 3, a reticulum-cell sarcoma of the epipharynx with cervical metastases, received a tumor dose of 4,770 r ("reduced," 3,200 r) and a skin dose of 4,400 r ("reduced," 2,900 r). There was no late damage after five years. Case 4, cancer of the penis, received a dose of 5,300 r ("reduced," 4,000 r). Three years later there was gross atrophy with parakeratosis and epithelial hyperplasia of "partly precancerous shape." In Case 5, actinomycosis, the skin dose was 4,800 r ("reduced," 4,000 r), with no late damage after six years.

The author believes that Zuppinger's estimate of the effect of the time factor on the dose in protracted irradiation is accurate.

LEWIS G. JACOBS, M.D.

Inactivation of Malarial Parasites by X-rays. B. E. Bennison and G. Robert Coatney. Public Health Rep. **60:** 127–132, Feb. 2, 1945.

Sexual and asexual forms of *Plasmodium gallinaceum*, an avian malarial parasite which produces uniformly fatal infections in young chickens, were irradiated *in vitro* by x-rays (200 kv., 20 ma., no filter, 20 cm.

distance, 1,450 r per minute). Trophozoites were inactivated by 20,000 r but not by 10,000 r; sporozoites were inactivated by 8,000 r but not by 6,000 r. Trophozoite suspensions exposed to 2,000 to 8,000 r produced infections characterized by lengthened prepatent periods and lengthened survival times.

Therapeutic irradiation of infected chickens (200 kv., 20 ma., 0.25 mm. Cu + 1.06 mm. Al, 40 cm., 68 r per minute) had no significant effect on the outcome of the infection.

Human blood infected with *Plasmodium malariae* and exposed to 5,000 r failed to produce an infection in a susceptible patient.

Experimental Roentgen Injury. I. Effects on the Tissues and Blood of C3H Mice Produced with Single Small Whole-Body Exposures. II. Changes Produced with Intermediate-Range Doses and a Comparison of the Relative Susceptibility of Different Kinds of Animals. III. Tissue and Cellular Changes Brought About with Single Massive Doses of Radiation. IV. Effects of Repeated Small Doses of X-rays on Blood Picture, Tissue Morphology, and Life Span in Mice. Paul S. Henshaw. J. Nat. Cancer Inst. 4: 477–484, 485–501, 503–512, 513–522, April 1944.

A series of experiments is recorded in which the author sought to correlate certain blood and tissue changes due to roentgen irradiation on a time basis. The first studies were of alterations produced in C3H mice by whole body irradiation with a single dose of 50 r (200 kv., 20 ma., 0.5 mm. Cu and 1.06 mm. Al, 105.3 cm. distance, 8 r per minute). Faint but nevertheless detectable blood and tissue changes were observed. A slight leukocytosis developed in two to four hours, followed within eight to twelve hours by a mild but persistent leukopenia, due largely to a reduction in lymphocytes. A small amount of nuclear debris was seen in the lymph nodes at two to four hours, but this disappeared and a mild hyperplasia occurred in eight to twelve hours. The seminiferous tubules of the testis showed a significant reduction in spermatogonia and primary spermatocytes at one week and of secondary spermatocytes at two weeks. Regeneration took place and the tubules appeared normal in four to six weeks.

Mice and guinea-pigs were then submitted to larger doses—those commonly used in therapy—up to 400 r. For the mice the factors were as in the earlier experiments except that the distance was reduced to 50 cm., making the intensity 38 r per minute. For the guinea-pigs two x-ray beams were employed and the intensity was 71 r per minute. Generally changes of the same kind were observed in the peripheral blood, lymph nodes, spleen, bone marrow, and testes in both the mice (two strains) and guinea-pigs, consisting in a loss of functional cell elements followed by a slow return to normal if the damage was not too severe. All the animals showed a fall in the lymphocyte level. The neutrophil level was also reduced, but with certain differences in the three groups. Lymphoid tissues showed loss of small lymphocytes in the first twenty-four hours, with return to normal in two to six weeks or longer. There was a similar loss of parenchymatous cells in the bone marrow, resulting in the formation of extensive blood sinuses, with recovery extending over six weeks or more. In the testes the first elements to disappear were the primary spermatocytes. With the higher doses these were completely lost and there was a distinct thinning of spermatogonia. As time passed, the secondary spermatocytes disappeared, owing in part or entirely to further maturation. Regeneration took place through reappearance of the cell types in the order of maturation—spermatogonia alone first, then spermatogonia and primary spermatocytes, and finally all three types, with the eventual appearance of mature sperm.

Comparing the observation on the different tissues, the author concludes that in each instance regeneration started from primitive cell forms that had survived irradiation fatal to other cells. As in the earlier experiment, leukocyte reserves appeared to prevent the peripheral blood picture from reflecting exactly the condition of the hematopoietic tissue in those animals receiving low dosage. Incidentally, the differences in response of the different groups of animals were sufficient to indicate the necessity of using homogeneous groups for critical studies.

In a third set of experiments, on mice, guinea-pigs, and rabbits, much larger amounts of radiation were used, 25,000 and 50,000 r being given in a single dose at an intensity of 250 r per minute. With such massive doses, "the devastation produced in the animal's tissues in the brief period of 3 hours was almost unbelievable. There was no tissue in the body which did not suffer; even the most resistant of tissues such as brain and muscle showed marked damage." Guinea-pigs exposed to 50,000 r died approximately three hours after irradiation was begun; rabbits died in three to six hours after irradiation; mice in twenty-four to forty-eight hours. Death appeared to result from a distinctive type of shock quite apart from that usually seen following trauma, burns, and other injuries. It was characterized by generalized toxemia, hyperthermia, hyperesthesia with intermittent seizures, and cyanosis. Tissue sections showed extensive nuclear and cytoplasmic degeneration followed by parenchymatous cell loss.

Finally mice were treated with repeated small doses of radiation, 5, 10, 15, 20, and 25 r being given daily until the death of the animal (8 r per minute). Various progressive and terminal changes were observed. There was a fall in leukocyte level due mainly to lymphocyte loss and varying progressively as treatments proceeded and directly with the size of the daily dose. Shortening of the life span was noted, the degree of which also varied with the daily dose. Leukemia developed in some of the mice receiving 15 and 20 r daily.

Experimental Roentgen Injury. V. Effects on Hematopoietic Reserves and Regenerative Capacity. Paul S. Henshaw, Jean W. Thompson, and Henry L. Meyer. J. Nat. Cancer Inst. 5: 233–247, February 1945.

The experiments described here (continuing the studies described in the preceding abstract) were designed to deal with subliminal effects of radiation and the reserve capacities of certain tissues. Two-to-three-months-old C3H mice were used exclusively. Samples of 40 animals were given single acute doses applied to the whole body. The dosage pattern was as follows: 12 1/2 r administered twice weekly, 25 r once weekly, 50 r at fortnightly intervals. In addition to the preceding dosages, 100, 200, and 400 r per treatment were employed.

The lymphocyte level was used as a guide. Treatment was continued until the lymphocytes dropped significantly below 4,000 cells per cubic millimeter, at which time they were discontinued until the lymphocyte level rose above 4,000 for two consecutive weekly counts. The following trends were revealed: (1) The number of treatments required to lower the lymphocyte level to 4,000 or below became less and the period of recovery became longer as the experiment progressed. (2) Eventually all of the animals tended to pass into a persisting lymphopenia. (3) In each case, irrespective of the size of the treatment dose, this condition occurred when the accumulated dose reached 300 to 500 r.

ELLWOOD W. GODFREY, M.D.

Effect of Ionizing Radiations on the Broad Bean Root. V. The Lethal Action of X Radiation. L. H. Gray, John Read, and M. Poynter. VI. Summation of the Effects of Radiation of Different Ion Density. L. H. Gray and John Read. Brit. J. Radiol. **16**: 125–128, April 1943; **17**: 271–273, September 1944.

In these two papers, the authors continue the account of the experiments outlined in earlier contributions (Abst. in Radiology 41: 526, 1943). In the first they discuss the lethal action of x-rays on the root of the broad bean, *Vicia faba*, and in the second the effect of combinations of neutron and gamma radiation and of alpha and x radiation. The latter pair were the more thoroughly studied. The combination of neutron and gamma radiation was slightly more effective than either radiation alone, while the alpha and x radiation in combination were slightly less effective than either alone.

These findings confirm the theory that the lethal effect of all four radiations depends on the same primary injury and the efficiency depends upon the differences in the amount of ionization and the spatial distribution of the ions.

SYDNEY J. HAWLEY, M.D.

Experiments with Mammalian Sarcoma Extracts in Regard to Cell-Free Transmission and Induced Tumor Immunity: A Summary. Carl Krebs. Acta radiol. **24**: 190–197, June 15, 1943. (In English.)

This article is a summary of the work done by Krebs, Harbo, and Thordarson on mouse leukosis and published in full as a separate supplement to *Acta Radiologica* (Supplementum XLIV).

The object of the investigations was to find out whether experimental animals (mice) which had been inoculated with cell-free extracts, adsorbates, ascites fluid, etc., without developing tumor growth or leukosis, were more or less susceptible to subsequent abdominal inoculations with tumor-cell-containing ascites fluid than mice which had not been so pre-treated.

The results were different in two groups of animals. In the one group in which the animals had been inoculated with adsorbates of aluminum hydroxide, carbon or diatomaceous earth, there was practically no difference regarding the percentage of tumor "takes" between pre-treated animals and non-treated controls. In the second group, where the mice had been previously inoculated with cell-free extracts or their residual solutions, the proportion of cases in which the subsequent injection of ascites fluid produced tumor growth was so very much smaller than in the controls that it appeared probable that the pre-treatment with cell-free material had induced an increased tumor resistance.

Among the experiments carried out was one in which the tumor-cell-containing material was irradiated prior to inoculation. Growth was obtained in 6 cases after irradiation with at least 4,260 and 6,860 r, but tissue irradiated with larger doses gave negative results. Since much greater amounts of radiation are required for the inactivation of a virus than of tumor tissue, the results obtained are not considered sufficient basis for assuming a virus as the cause of the tumor in question. Other experiments pointed to a similar conclusion.

E. A. SCHMIDT, M.D.

Studies on Synergism of Leukemogenic Agents in Mice. Henry S. Kaplan and Arthur Kirschbaum. Proc. Soc. Exper. Biol. & Med. **55**: 262–264, April 1944.

Furth and Boon (Science 98: 138, 1943) recently reported a synergistic effect of methylcholanthrene and irradiation in the production of leukemia in Rf/Ak hybrids. In the present study, strain Dba and strain F mice were used to determine whether this observation held true in other susceptible mice. The strain F mice received a total of 720 r whole body irradiation in nine daily doses of 80 r (140 kv., 30 cm. skin-target distance, 2 mm. Al filter), while the more hardy Dba animals received a total dose of 880 r. In one group of mice, irradiation alone was used, in a second 0.5 per cent methylcholanthrene was applied percutaneously twice weekly, and a third received both types of treatment, the first application of carcinogen being given on the first day of irradiation. It was found that irradiation in conjunction with methylcholanthrene failed to increase the incidence or accelerate the onset of carcinogen-induced leukemia in the strains studied.

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RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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Volume 45

July—December 1945

Owned and Published as its Official Journal by
THE RADIOLOGICAL SOCIETY OF NORTH AMERICA